A MANUAL OF TIME AND MOTION STUDY

A PRACTICAL GUIDE TO THE MEASUREMENT OF HUMAN ENDEAVOUR IN INDUSTRY AND TO THE DEVELOPMENT OF PRODUCTIVE EFFICIENCY

BY

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CONSULTANT IN TIME AND MOTION STUDY

WITH A FOREWORD BY

B. SEEBOHM ROWNTREE

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FOREWORD

NEVER in the history of British industry has it been more importan than it is to-day to raise the standard of efficiency. If we are t compete successfully in world markets we must produce the good which those markets require at prices which people are willing t pay. But we must not lower our costs of production by lowerin wages. We want full employment in this country, but we also war a rising standard of living.

Mr. Hendry's book makes a valuable contribution to the problei of how to raise the standard of efficiency in industry in two dire(tions: first, by giving an incentive to workers to do their best and second, by avoidance of all preventable waste.

His chapters dealing with the human side of the problem of tir and motion study are excellent, and should be widely read. Tl bulk of the book, however, is devoted to the technique of the scien(about which he writes, and this will be found invaluable to tho: who are engaged in time and motion study. The book should find place on the shelves of all industrial managers, but it should n(rest upon these shelves. it should be taken down frequently f(careful study

B. SEEBOHM ROWNTREE

BSR/ER
15th December, 1944

PREFACE

TIME Study as a measurement standard and Motion Economy as an aid to the efficient use of labour are two subjects which are growing more and more in importance. The effective prosecution of the war tended to lead our eyes away from the cost of production and the introduction of incentives was not always followed by an immediate jump in production.

However, the war won and the battle for export well in gear, the need for the immediate replacements of so many of the necessities, to say nothing of the semi-luxuries and luxuries, will once more mean that firms and organizations will have to consider the cost of manufacture and selling. Motion study will be more important; then time study will be even more necessary.

Our friends in the U.S.A. are more advanced in these two aspects of scientific management and treat them with greater detail. However, when I came to write this book, it seemed that what was particularly needed was a practical application of the principles rather than treatment covering every detail of time and motion study; or, in other words, some sort of "route indicator" by which those as yet unfamiliar with these two branches could be enabled to find their way and develop their own technique.

The reader will detect a bias in the book towards the application of time study and motion economy to the assembly benches. This is because I believe that, while the machine shops and the feeder shops need a close study and application of motion economy, nevertheless it is in the "free" motions and physical output of the assembly benches and shops that the highest return will be found.

This book has its limitations; the subjects are so vast, the implications so varied, that I am acutely conscious that in a work of this size they cannot be dealt with as fully as they deserve. Nevertheless, it is hoped that those who read this book may be sufficiently tempted to explore the subjects further and thus gain from their studies a practical insight into one of the most fascinating aspects of management to-day.

I am indebted to so many people for their kindnesses in critic

and constructive help that I apologize for not being able to acknowledge them more fully, but I would like particularly to express my gratitude to Mr. R. I. Crook, Management Engineer, for his assistance and many suggestions.

J. W. HENDRY

PREFACE TO THE SECOND EDITION

As this preface is being written, the claims by organized labour for a forty-hour week and no reduction in pay are becoming more urgent.

If we are to avoid prices so rising that nobody is better off for higher wages in the long run, we must ensure that output per man-hour is enhanced. Time and motion study helps towards that end. Time study because it evaluates a fair day's work; motion economy because it enables more output to be given with less physical effort.

With the present political set-up, it is more necessary than ever that labour, that is, organized labour, should justify itself, and one such way is to produce more goods in less time so that all of us can enjoy more leisure with more money to spend on it. This is the ultimate ideal; but it can only be achieved by harnessing every second of working time and employing every efficiency device.

It is an inescapable fact that only by production at low wage costs (as distinct from low wage rates) can high earnings be maintained. Time and motion study gives a pointer to this fact.

JOHN W. HENDRY

CONTENTS

CHAPTER VII

CHAPTER VIII

CHAPTER IX

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

A MANUAL OF TIME AND MOTION STUDY

CHAPTER I

NEED FOR A STANDARD LABOUR MEASUREMENT

ALL branches of industry require standards of measurement peculiar to their particular needs. Hence the growth of the measuring instrument in all its varied forms. It would be safe to state that at no other time has the standard of measurement been needed as much as it is to-day. Accuracy is the keynote in production; without accuracy the complex industrial machine of the twentieth century would never have grown to such formidable proportions.

That which labour produces is measurable. Except where experience guides, that which labour is *expected* to produce has, up to this time, remained incalculable.

A YARDSTICK FOR LABOUR

It is the correct assessment of the limits of labour in relation to production that has been the difficulty in correct costing and the anticipation of the rise and fall of a labour supply curve

All branches of industry have their methods of handling this problem, but most of the methods are inaccurate, due to the fact that experience alone has been the guiding principle It is easy to see that the individual's own judgment can often be at fault; when used in connexion with the assessment of labour requirements, this can be a very costly business. When one appreciates that all forms of production consist of labour expenditure in some form, and nearly all production costs are composed of labour costs, it will be readily seen that the correct estimation of labour is of paramount importance.

Labour costs are the main charge against industry, and therefore any contribution to the reduction of this charge becomes a valued asset.

How can measurement be applied to labour in order that the costs may be reduced? It is not sufficient to be able to measure the output of labour; the standard must be carried a stage further

and the "yardstick" applied, so that a fluctuating labour supply or demand is avoided. To carry an excess of labour solely for the purpose of guarding against short supply is a very expensive insurance policy, the premium of which is likely to represent the difference between profit and loss.

Measurement of labour is now a recognized science in industry. More and more firms and organizations are becoming aware of the pressing need for accurate forecasting. In the same way as market research has removed many of the hazards from selling, so time study is removing many of the hazards from labour and cost control.

The maintenance of labour pools, and the unhealthy alternative of cutting redundant labour during slack periods, are two evils that add immeasurably to the difficulties of running a business successfully. There is, however, a greater responsibility than these, and that is the fact that a fluctuating trade brings instability to the worker, with the result that either the best type of worker leaves that particular industry or, if the labour market is over full, a high labour turnover is the unhappy result.

Time study, with its correct evaluation of labour requirements, permits planning that can be applied with due regard to seasonal fluctuations, thus doing a great deal to mitigate the evils consequent upon over- or under-production.

Time study, however, has an equally important task to perform to the mere setting of standards. It has to establish a working measurement between the employee and the employer that will be acceptable to both. It is to be used as a method of calculating the payment of wages and dues. By its inducement or opportunities for an incentive scheme, it provides a reduction in overheads benefiting both the worker and the employer.

It would be wrong to assume that time study is the panacea of all business ills, but it serves an extremely useful purpose in focusing the spotlight upon both the worker and the conditions under which the worker performs his task. This, too, is of importance, for it is as necessary to set a standard of producing as it is to set a rate of production. Time study can ensure that the right method is being used from the beginning. Not only this, but used in conjunction with motion study, it does a great deal to ensure that all the time-wasting factors are eliminated.

Time study is a measurement of labour carried on with due consideration for the skill and speed of the worker; it takes into account the special difficulties under which the worker labours; it ensures

that the correct proportion of relaxation is allowed and is taken at the correct time. It is no use having workers slowing down at the end of the period due to tiredness; this upsets the tempo of the factory or workshop. To ensure a continuity of production, it is imperative to apportion the amount of work accurately, and time study permits this to be done.

MEASUREMENT AND INCENTIVE

Time study provides the foundation for an efficient incentive scheme. All incentive schemes are based on the worker being able to exceed a given target, and it is the amount by which the target is exceeded which determines the efficacy of the incentive. Quite obviously it is absurd to make the target so easy that the worker can exceed it so much that the making of money or bonus is done without effort. This destroys the point of any incentive, apart from the fact that the costs will increase out of proportion to the production. On the other hand, it is equally undesirable to set so high a target that the operator loses heart and is prepared to make just the base rate which in most cases is guaranteed.

Time study must be efficient. There can be no half-way measures about this. If the time study staff is badly trained, then both the management and the workers lose faith in the scheme. It is imperative that as much care be lavished on the equipping of the time study department as on equipping a toolroom.

It has already been shown how the time study will help in the forecasting of costs and production; it is in this direction that the accuracy of the department must be without question, for serious consequences will result if the time study standards are at fault.

MOTION STUDY: ITS RELATIONSHIP TO TIME STUDY

Motion study is a corollary of time study. The analysis of methods or motions is of no less vital importance. Unless the correct methods are being used or the most efficient motions have been established, the standards for future production programmes will be based on false conceptions. These standards will be of value only so long as the correct methods remain undiscovered It is then up to the operator or the junior supervisory grades to find out more efficient methods, which always happens sooner or later. When it does happen, all the standards are immediately upset, thus throwing a greater strain on the time study department, which has to produce fresh standards, and also it provides a basis for the suspicion that

the rates are subject to alteration. This is a bad thing psychologically, because it breeds suspicion in the operators' minds, with the result that wholesome co-operation is absent.

This then establishes the following sequence: motion study, to analyse the motions and methods, which will include tooling and jigging, and to deduce from the study the correct and most efficient methods; motion economy, to put into practice the results gleaned from the previous study and to ensure that the correct procedure is not only laid down but is adhered to; time study, to establish standards of time upon which will be based the number of parts to be produced per hour and to provide data upon which correct costing and labour assessments will be built.

Due to the fact that time study has been mostly used in connexion with the application of incentive or bonus schemes, a great deal of friction has been caused in the past. Apart from the relative importance of the incentive application as a cost controlling factor, friction will always be engendered where incentives are involved, due to the fact that incentives, as such, have a direct bearing on the worker's wage packet, and this, naturally, is of tremendous importance to the worker.

REWARDS

Whatever the status of the worker, however highly graded or lowly graded he may be, it is a perfectly natural expectation to assume that whatever tasks he performs, the reward will be in proportion to the amount of work produced. It is the amount of expected production that forms the basis of all arguments and friction between the worker and the time study department. Every time the standard is altered, the worker wonders what difference it will make to his pocket. Each time an operation is time-studied, the worker is consciously exploring the possibility of getting an easy rate, and this factor must be recognized. This statement is not necessarily based on the fact that the worker is fundamentally dishonest. The worker is performing his task for, broadly speaking, one reason only—to earn a living. Anything that might tend to reduce this is suspect. The truth of all the literature produced by various well-meaning personnel managers and welfare workers on the co-operation between worker and management can be proved only if the worker is assured that this co-operation will do neither of the following—

(*a*) Make him work harder for the same money.
(*b*) Reduce his earnings.

Remove this suspicion and the worker is yours for ever in this matter of co-operation. Until this is done, there will be a constant battle, silent, maybe, but sometimes vociferous, between the time study department and the worker.

Because time study is used in most factories solely as a means of establishing standards upon which the incentive scheme is based, this suspicion is constant. If the factories which so far have only used time study in this connexion would start using it in order to improve working conditions, to reduce overheads, to restrict indirects, and to step up progress methods, then a great deal would be done to remove suspicion of rate cutting

Because of the delicate position held in management by the time study department, all its personnel should be considered ambassadors and behave accordingly. No matter how brilliant he may be, the time study observer, because of his peculiar position, must be a failure if tact is not one of his virtues.

Operators are normal beings and, whatever their status, education, or outlook, they all have one thing in common, a sense of monetary value, which is often keener than the average time study man's, due mainly to the fact that the operator's standard of living is lower, and shillings to the worker must have a greater significance than to the time study observer.

This position must be faced. Time study is a realistic business and it is good to ensure an outlook based on realism. Idealism plays its part in business, but it is much safer to rely on finding the operators as they are than to expect them to conform to an illusory code of ideals which bears no relation to fact. If it is recognized that operators are likely to be non-co-operative, then at least a start can be made from the time study angle to earn goodwill, whereas if the expectation is that co-operation will be automatically forthcoming, no effort will be made to ensure it, with the result that confidence will be a long time in becoming established.

Time study in the past has been associated with "speeding up." Many of the misunderstandings engendered were due to the fact that the normal operator objects to being "speeded up." It is a reflection upon his ability and an implied criticism of his previous efforts. If the operator is a craftsman, it naturally follows that he takes a pride in his work. The thought of speed is abhorrent to him, and thus at once antipathy results. *Time study should not be based on this "speeding up" process.* Some employers, short-sighted ones, of course, look to time study to yield higher speed per operator, and

are only interested in their incentive scheme because they think that this is a means of "speeding up."

Time study owes most of its difficulties to this popular conception. Increased output is not necessarily the result of increased speed. Very often the rhythm has been established with the result of better planning of the job; tooling and methods investigation also improve output. In a large number of cases the operator is unaware that he is working faster, due again to better conditions. "Speeding up" is something to be avoided. If the job is right; if the conditions are right; if the base rate or target is right; and, finally, if the operator is satisfied that he is getting a square deal, then the speed must follow as a matter of course.

Training, too, plays an important part in the making of speed. If the operator can be shown a better method, and can be "sold" on the idea that this is less fatiguing, then again speed will follow naturally.

Distinction should be drawn between working fast because the target set is a distant one and working fast because the operator wants to do so. In one case it is very much the example of the donkey being kicked along, and in the other a carrot being held before the nose. After all, it is the hope of reward that sweetens labour.

Time is a measurement. This must be clearly understood. It is not the reason for time study, time is the one constant factor which can be used as a measuring instrument. Its use is to be the yardstick of output; not, mark you, of energy or skill or ability or speed —merely output. So many parts can be produced in an hour, or have been produced in an hour.

Time is a value. In itself, it does not comprise a standard; it must be tied to other methods of calculation. Average alone is not a true enough guide, and time must be used in connexion with other values, such as the individual operator's speed, his skill, and the conditions under which he labours. When all these have been correctly assessed and applied, with time as a measure, then a standard has been produced.

The standard having been produced, it is then possible either to assess the future production or to measure the present rate of production.

Assessment of the future production will permit of an accurate forecast to be made of personnel and machinery. It is then up to the production manager to decide whether the number of machines will be increased to achieve the target, or whether the target will be

adjusted to the time-standard in order to use existing machinery with less labour. This factor depends entirely upon the programme.

In any case, when the schedule has been produced, the time-standard will be used as a basis for the incentive.

Bearing in mind that the time-standard has been set on the expected output from an average operator, working under either existing conditions or forecasted conditions, and at an average speed, the base rate will be set so that the operators will be able to earn bonus on the *extra* number of parts produced—extra, that is, to the number of parts called for on the time-standard.

THE INCENTIVE SCHEME

What is an incentive scheme? It is a scheme designed to *reward* extra output. If an employer engages a man to do a certain job, say at 2s. per hour, then that employer can reasonably expect that the operator will perform his task sufficiently well to produce at least 2s. worth of work in every hour. Similarly, if the operator produces 2s. 3d. worth of work in every hour, he is entitled to assume that his extra endeavour will be suitably rewarded. This can be done by means of a merit award every so often in the form of an increase in rate of pay. But one objection to this is that it does not effect an accurate control over costs, since it is obvious that the rate of increase of output may not be constant; that after the first flush of enthusiasm the production ratio to hours may decline. An incentive scheme provides a fair way in which to reward endeavour and at the same time penalizes the bad or slothful worker.

An incentive scheme provides a psychological urge as well as satisfying the law of cupidity. There is a great deal to be said for providing an outlet for the naturally dominant sense of competition that is in all of us; workers are more interested in their jobs if the spirit of competition is bred and a means provided for an accurate measurement of efficiency.

From the employer's point of view, an incentive scheme is a worth-while investment. It means that although extra money is being paid in the form of wages, the return is greater in proportion to the initial cost because of the saving in time, which of course means an immediate reduction in overheads, and, what is of very great importance to a machine-burdened industry, the percentage of machine-efficiency is increased. This fact cannot be stressed too highly. The need for a high ratio of efficiency per machine is a fundamental one in industrial economics.

Another important aspect of the incentive scheme is that its

tendency is to reduce the percentage of rejections. Obviously an incentive can only be payable on good parts, and this in itself makes the adoption of an incentive scheme worth while.

ANALYSING REWARDS

What form shall the incentive take?

There are many forms of incentives and, in general, these can be analysed as follows—

Naturally, the main incentive to work at all is based on the fact that one must work in order to live, equally with this there are patriotism, self-interest, loyalty to the firm, and a normal sense of honesty and ambition.

Firms can reward the worker by other inducements, in addition to the base or hourly rates. There are—

(*a*) **Merit Award.** This is self-explanatory. It is based on the theory that year by year the employee becomes of greater value to the organization by reason of his greater experience, increasing responsibility, and willingness to serve, and again by virtue of the fact that employees must have some sort of anchorage or else the result will be a high labour turnover.

(*b*) **Special Awards.** A large number of firms adopt the policy of giving bonuses for special effort, and others with a more philanthropic attitude give a bonus based on increased profit which they think the employee has a right to share.

(*c*) **Paying an Annual Bonus.** This is based on such things as absenteeism, time-keeping, special contributions in the way of suggestions, etc.

(*d*) **Payment by Results.** Here is the *raison d'être* for incentive schemes. The operator is allowed a certain amount of time in which to do a job and, whatever time is saved, it is paid for. There are several methods of applying this system and these will be discussed in detail in the following chapter.

To analyse the foregoing systems, we see—

(*a*) This laudable scheme can be applied to all classes of worker. One disadvantage, however, is that it can be abused both by the worker and by the junior administrative staff. It can be abused by the worker who can produce exactly the same amount of work as before the award was made, which after all is easy enough to do since all of us are creatures of habit; or it can be abused by the foremen when its withholding is used as a threat. Threats and penalties are poor companions in industry; friction results and a falling off in enthusiasm is inevitable.

(*b*) The weakness of this lies in the fact that no allowance is made for individual qualities. The bonus is lumped together and all benefit, deserving and undeserving alike. In these days of greater and greater output, with the correlated demands for economy, it is essential that the operators should *feel* that the awards are justly apportioned.

(*c*) This is a very good way of rewarding special virtues, but it should be restricted to the virtues and, even where there is an incentive scheme in operation, giving increases for special contributions to the welfare of the firm as a whole is an idea that builds up an *esprit de corps*.

(*d*) Payment by results has much to commend it. The methods sort out the "wheat from the chaff" in a most fair manner. The system gives the worker a personal incentive; it is a means of correctly rewarding all types of workers, good, bad, and indifferent.

CHAPTER II

METHODS OF APPLIED INCENTIVES

As explained in Chapter I, there are many ways in which an incentive scheme can be applied.

In industry to-day there are two principal types of incentive—

(*a*) Premium Bonus Scheme.

(*b*) Standard Times.

In both of these, time-standards are required and accuracy is necessary from the outset.

In both, too, targets are set whereby the operator is made aware of the number of pieces per hour expected of him. This is based on the time-standard, and is the normal expectation for which the hourly rate, or base rate, as it is sometimes called, is paid.

In both of the schemes, the operator receives extra money for the amount of time that is saved. The actual percentage of bonus, however, is the main difference between the two schemes.

THE PREMIUM BONUS SCHEME

In the premium bonus scheme, the operator receives a proportion of the time saved in the form of money; in the standard times scheme the operator receives the whole of the time saved, converted into money and expressed as a percentage of the base rate.

Here are some examples—

HALSEY

The first to be described is based on Halsey's system and it provides for controlled bonus earnings. A basic output is prejudged and the operator has to beat it. By whatever amount the target is beaten (or, of course, by what amount of time) the operator shares with the employer the amount of saving. Usually it is based on 50 per cent. Thus, if the time allowed is 16 hours to do a certain job, and the operator, by working harder, faster, or by using better methods, does the job in 12 hours, then the saving of 4 hours is shared; that is, the operator will receive 14 hours' pay for 12 hours' work. This system has little to commend it since it breeds distrust and the operator, if he is normally intelligent, soon realizes that the employer is getting a share of the operator's own efforts over and above that to which the employer, apparently, should be normally entitled.

The exercising of this controlling factor in an incentive scheme

is to nullify many of the benefits that would be normally expected. The operator naturally feels that he is not getting a square deal, because the harder he works the less he is likely to get in direct relation to the amount of work performed.

Another cause of its unpopularity is that the reason for its adoption some years ago was because the employers showed little faith in the time set by the rate-fixer. This certainly had some justification, because the more scientific study of timing had not at that time arrived at the degree of accuracy which to-day it enjoys.

Very often, too, the rate-fixer, since he had to rely upon a system of mutual acceptance, set a rate that was certain of acceptance. Again, Management, being well aware that methods left a lot to be desired, rather than have a proper methods department preferred the arbitrary methods of setting rates, knowing full well that under the system employed it could not lose on the deal; even if the operators worked out their own particular method, it did not matter very much if the operator made high bonus, because the employer shared it anyway. This was a clear case where a poor incentive scheme brought in its train the evils of bad planning and lack of proper methods. These methods have not yet entirely disappeared.

ROWAN

Rowan's system is perhaps the next best known. Under this system, which also exercises a control of the bonus payable, the operator does not physically share his bonus, but the adjustment is based on time taken. For example, if the operator is allowed 16 hours to do a job and takes only 12 hours, the difference in time is shown as 4 hours. Four hours, then, is expressed as a percentage of 16 hours, which was the time allowed. Thus 25 per cent bonus becomes payable. The bonus is payable on the time taken, so that the payment is actually for 3 hours. The above point should be noted. Rowan's system is more favourably inclined towards the operator than is Halsey's, but even so, the operator is still not receiving the full benefits from his saving of time. One thing must be put forward in favour of the Rowan system, however, and that is the fact that the time values are usually compensated in order that the operator may be able to reach rapidly a stage where bonus can be earned. For example, supposing that the actual time value was, as we have seen in the previous instance, 16 hours, this *could be increased* by 16 per cent in order that the operator might be certain of making *some* bonus. The effect of this is to encourage

the operator over the difficult first stages. *Should* the operator still be able to do the job in 12 hours, then the bonus percentage payable on 12 hours (time taken) and against the complicated allowed hours, i.e. 16 + 16 per cent = 18·56 hours, is 35·4. The actual percentage adjustment that is made to the time value is, of course, a matter for each individual industry and/or firm.

Some organizations adopt the principle of fixing a minimum bonus in order that operators shall always be in receipt of a guaranteed wage. There is no need to control maximum limit since under the Rowan scheme it is obvious that "double time," i.e. 100 per cent bonus, is an impossibility. The philanthropic attitude of the employer in connexion with the "guarantee" has much to recommend it from the point of view of personnel relationship, but it is not a sound economic principle. Either (*a*) the operator who is not particularly skilled does not attempt to improve, with the result that if he is working on a machine, the machine-efficiency is upset, or (*b*) the analysis of operator-efficiency can only be reckoned from x plus instead of from zero.

One very big advantage of the Rowan system is that it permits a greater latitude in the matter of setting the rates. Accuracy, while important, nevertheless need not be so highly stressed as under the standard times scheme. Another point to make is that if the methods change the rapid increase in bonus is not so embarrassing to Management, and the decision as to "blocking" a payment or releasing the full amount until the job has been investigated does not arise. This is a real advantage for those organizations which are not sure of the efficiency of the time values, as it enables an incentive scheme to be put in without the risk of paying money on loose rates, since, as has been demonstrated, the bonus being calculated on the time allowed and translated into a percentage on the time taken, completely eliminates the risk of the 100 per cent bonus and over.

It naturally follows that there is a tendency for a reduction in effort or speed, or both, due to the fact that if the results were plotted on a graph it would be seen that there is a rising curve of bonus earnings from zero to 35 per cent, after which effort becomes much greater, so that as the curve flattens it follows that the amount of extra energy required to make more bonus just simply is not worth its expenditure. (See Fig. 1.)

Still, the system has a great many advantages, and serious thought should be given to it if there is to be any change in rates. This is because a change in a rate to the operator's detriment,

consequent upon change of method, etc., is not nearly so much in evidence as under the standard times scheme.

Apropos of rate changing, it is an established custom that unless the method or the material or the inspections standards alter, rates are unalterable. If the bonus being earned is too high, through a miscalculation on the part of either the clerk or the rate-fixer, then the rate should be admitted. There is a very good reason for this. Obviously, if the operator once gets the idea that if he earns high bonus time allowed will be cut, the maximum output becomes an impossibility. This has a serious reflection upon the machine tool efficiency. For this reason alone, apart from any consideration of justice to the operator, rates once set should never be altered to the operator's disadvantage.

STANDARD TIMES

This is one of the fairest of the incentive schemes. Strict accuracy is the keynote of it, but once accuracy has been established then it benefits the operator to the maximum extent, and it gives the employer the advantage of knowing that maximum output per operator and maximum machine efficiency are *ipso facto* a possibility.

There can be no question of the operator not feeling that he is getting a square deal. He realizes that every minute of the day he is working he is able to *earn* unlimited bonus. The effect of this upon the output is considerable. The Management too are well aware that rejections will drop to zero, and that the operator's efficiency will be as near to 100 per cent as it is possible to be.

This scheme, however, has one or two disadvantages. Firstly, only scrupulous accuracy will give satisfactory results. If the rate-fixer is setting loose rates, i.e. rates that can be easily met, then obviously inordinately high bonuses will result with a consequent lowering of efficiency. Secondly, operators who find that they can make bonus easily, cannot be expected to try for the "ceiling"; they will be content with something half-way. Yet another apparent disadvantage is that owing to the fact that the operator receives all that he saves, squabbles between the operator and the rate-fixing department are common. The operator will naturally do all he can to get a rate eased, while some rate-fixers will endeavour to squeeze the last ounce out of the operator. But these objections can be remedied, and it is up to the Management to ensure that the rate-fixing department is not only accurate but is well run. If the Management can have faith in its rate-fixing department, then it follows that the operators will soon learn to share that faith. If,

however, the Management is weak and prefers not to back the rate-fixing department in order to avoid friction with employees, then the operator will soon realize that he can obtain the maximum advantages, and an operator will not be slow to see that this is accomplished. (Of course, this case refers to shop supervision.) It is with the shop supervision that the success of the scheme lies. Indeed, this can be said whatever the system employed. If the shop supervision is weak, then the rate-fixing department, by the very fact that it knows it will not be supported, must in time become weak also. This is an important point.

Under the standard times system, if the operator is allowed 16 hours in which to do the job and takes 12 hours, 4 hours have been saved. It is this 4 hours which is paid to the operator. Here is a comparison then of the relative values of all three systems, based on the common example of 16 hours time allowed, and 12 hours taken to do the job—

HALSEY

Bonus actually paid: 2 hours or 16·66 per cent on time taken.

ROWAN (net, i.e. uncompensated):

Bonus actually paid: 3 hours or 25 per cent on time taken.

STANDARD:

Bonus actually paid: 4 hours or $33\frac{1}{3}$ per cent on time taken.

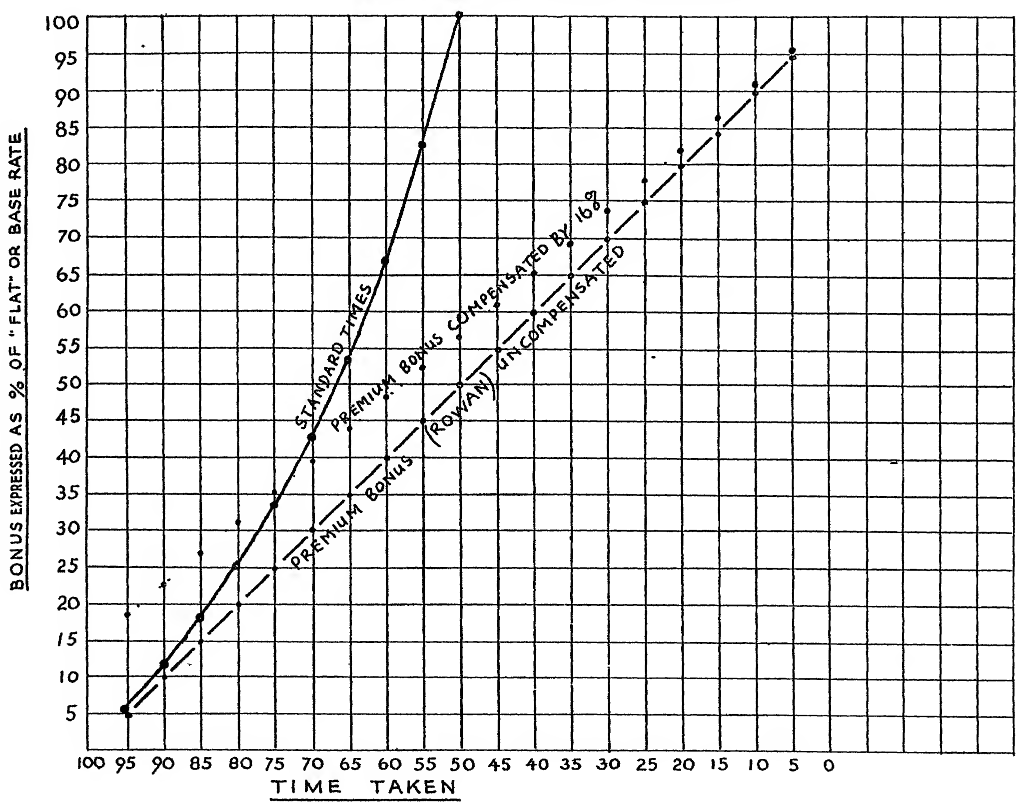
On the Rowan compensated scale, 4·25 hours would be paid, which is 35·4 per cent of the time actually taken. This apparent advantage over the standard times scheme is outweighed by the fact that whereas there is no limit to the bonus that may be earned on standard times, the Rowan scheme progressively asks for greater effort with a diminishing return for that effort. (See Fig. 1.)

It is now easy to see which system reacts most favourably in the operator's interest.

In Chapter I time study has been dealt with at some length; in this chapter, the term "rate-fixing" has been the operative word. The reason for this seeming paradox is that it was necessary first to trace the development of the incentive scheme, for which rate-fixers were primarily responsible.

Rate-fixers can be used quite safely on all premium bonus schemes, but with regard to the standard times scheme a higher degree of accuracy is required. This is not to suggest that all rate-fixers are necessarily inaccurate in their time values, but it is seriously

COMPARATIVE BONUS EARNINGS



Fig

It will be seen that the Standard Times curve rises much more steeply according to the amount of effort, whereas the Premium Bonus (both compensated and uncompensated) rises on a more shallow curve and from the 75 percentage level the amount of extra effort required is clearly just not worth the reward.

suggested that the more scientific method of setting rates as evinced in time study is better suited to the task.

Time study, being the science of studying time, is better able to forecast correctly the time required to perform a task or a series of tasks. This is particularly true in connexion with the incentive scheme, where, as has been demonstrated, a close limit is required on rates, and time study properly applied can keep within these limits.

It should be noted that the introduction of time study to an organization which uses a premium bonus (Rowan) system does not mean that it is essential to switch over to standard times. The introduction of time study merely brings more accurate rating to bear on the job. Indeed, with those organizations which are diffident about launching into the standard times scheme, it might be as well for them to start off with the Rowan system, and then to change over when they feel that the time study department can be sufficiently trusted to supply the more accurate data necessary for correct values. Certainly it would provide an ideal opportunity to build up a library of proven standard times per operation, which for brevity is referred to as "synthetics." This library can be very useful, and can either be used as a means of setting future rates, or as a means of checking new rates that from time to time will become necessary.

MOTION ECONOMY

Time study, being the study of individual operations, will enable the practice of motion economy to be brought into effect. Motion economy is a science dealing with the elimination of wasteful or unnecessary motions, and the time study observer, because he is studying almost microscopically the motions and movements of the operator, is in a good position to observe the economics of the job.

Gilbreth, whose writings on the subject of motion economy are considered as one of the most valuable contributions to scientific management, has put on record that "there is no waste of any kind in the world that equals the waste from needless, ill-directed, and ineffective motions, and the resulting unnecessary fatigue. Because this is true, there is no industrial opportunity that offers a richer return than the elimination of needless motions and the transformation of ill-directed and ineffective motions into efficient activity."

Can there be any doubt about this? The study of motion economy is one of the most fascinating, important, and valuable contributions any one can make towards better management.

Its importance cannot be overrated. In the factory mass-producing parts, the saving of a fifth of a second on every part reaches an astronomical figure in a year. Motion economy is a corollary of time study and plays a most important part. With a good incentive, an accurate time study department, a sound and practical motion study, good tooling, and efficient methods, no factory can fail to make schedule with the minimum of labour costs.

However important motion economy may be, it is of no importance at all if there is no incentive to keep the operators performing the task in the most economical manner; this is where the time study and the standard hours scheme play such a prominent rôle.

Time study, to be effective, must be used in conjunction with motion study; motion economy, to be of value, must be used in conjunction with time study All three branches are interdependent, and no one branch can be separated without grave risk to all.

The time study engineer or observer, then, should also be a motion study man.

INVESTIGATING

Before the job can be studied with a view to applying an incentive, discovering standard times, assessing labour requirements, computing costs, or, finally, discovering faulty planning, the job must be carefully investigated from several angles.

The first point to check is: is the operation necessary? This is not so fantastic as it sounds; many a job being done in a factory is unnecessary. For instance, very often a deburring operation is asked for by Inspection, when the very next operation is reaming. Inspection see that the drawing calls for clean edges and promptly set a standard. This does not often happen in a small shop, but where the progressing calls for transfer to another section, or even to another department, this sort of thing is apt to occur.

Another fruitful field for investigation is the inspection standards. In a large factory, the inspectorate is inclined to reduce tolerances on its own volition, merely because it knows from experience that the next operation calls for close limits. This is all very well, but the next job has probably been studied and rated on the old limits, with the result that in the first operation, operators are doing more than is called for and have probably been given extra time because of inspection demands, and on the following operation the operators find that they have less metal to remove, while they in turn have been allowed time for the full removal. So this is a point that is well worthy of study.

How about feeds and speeds? If the job has been studied before, it is possible that the feeds and speeds over the passage of time have been increased. This will affect the bonus earnings and is a justifiable cause for re-study.

Safety? This is a most important angle. The Factory Acts are very strict in this respect. The time study observer should have a working knowledge of the Factory Acts in connexion with his particular section. If the job is studied and if subsequently it proves to be a "hazard," the time study department shares the moral responsibility, at least, of the accident so caused.

Local conditions? All the local conditions will need to be investigated, and the time study man will be in the favoured position of improving the worker's conditions if they are in need of improvement. This is a very useful way of earning co-operation! Very often it is a report from the time study department which first draws attention to a foul smell, or poor lighting, or even bad ventilation.

All these points should be the first considerations of a time study man. There are many other points, but they specifically concern the actual study, but more of this later. (See page 55.)

The time study man, because of his intimate relations with the employees, will be in the favoured position of being able to test the pulse of industrial life. For this reason he must develop the correct approach. (It will be seen from the foregoing that the time study engineer or observer will need a wide general knowledge and great experience, and it is for this reason that time study is rapidly becoming one of the best-paid branches of industry.)

Readers may question the use of "observer" and "engineer." This variance is due to the fact that engineering is not the only industry that uses time study. Clothing, catering, commerce, and distribution all use time study, so the title "engineer" cannot be loosely applied

CHAPTER III

THE TIME STUDY DEPARTMENT AND ITS STAFF

Now arrives the stage where it can be decided what the time study department requires in the way of personnel. The department itself is a part of the "oncost," and therefore needs to apply its own yardstick as a measurement of its own efficiency! The department must not be overburdened with staff, since this will represent a cost out of proportion to the money it is able to save on production and methods, etc. On the other hand, it must not be understaffed; this causes pile-ups in jobs waiting to be studied and, because the department is overworked, will result in a spate of evils in the shape of loose or tight rates, scamped studies without the scientific analysis needed to avoid wasted effort, interdepartmental friction, and a general lowering of personnel efficiency.

There is one great saving that any time study department can institute, whether it is a new department or an existing one.

In most firms it is customary for the time study observer to perform his own clerical work, i.e. work out reconciliations and write up his own studies. Clearly this is a waste of trained and skilled labour, and an unnecessary drag on the amount of service the department can offer.

Girl clerks can be quickly trained to perform all the auxiliary functions of time study. They can be taught to handle the mathematics involved in the working out and analysing of data; they can also be used to take overall times on the various production checks that are required from time to time, i.e those required to prove rates or establish production cycles.

It is as well to point out that there is no reason why women (*not* girls) should not also be trained to become efficient time study observers.

In any case, whatever the sex of the observer, it is still a waste of labour to have the staff perform its own clerical work.

Where the firm is large enough to possess a self-contained accounting department, then the comptometers or other calculating machines can well be used to extend the rates from the studies. It is necessary, in this connexion, to organize a rapid and efficient service, for this reason: when the operator has been studied, it is a normal expectation that the rate or target shall follow as soon as possible. Certainly output will suffer until it is produced because

the operator is working "blind" and, if the rate is not rapidly forthcoming, there is a likelihood of a loss in production, and, until the rate is known, there is no incentive for the operator. Hence the need for urgent delivery of the rate, time allowed, or target, whichever system is being employed, to indicate the expected output.

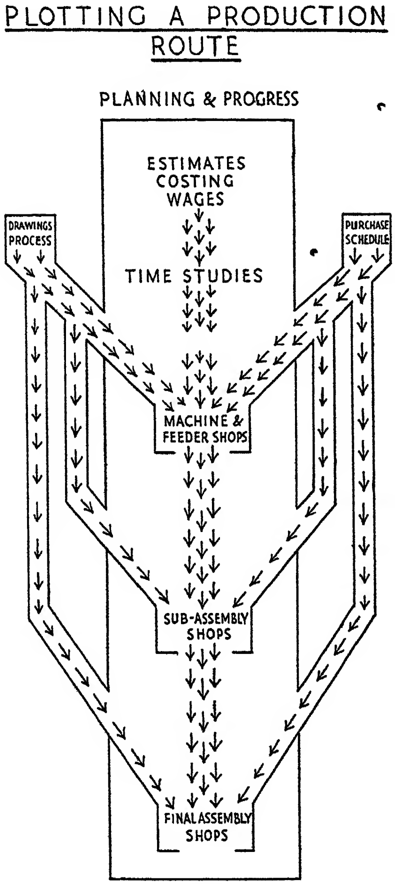


FIG. 2

The above route indicates a flow of work through an average factory and takes the opportunity of indicating the early stage in production where Time Study enters

STATUS

Whereabouts in the organization chart does the time study department come? Generally, it is lumped together with the planning department and methods. This is not necessarily its incorrect position. However, in view of the peculiar position enjoyed by time study, it is meet and right that time study should come fairly high up on the chart. (See Fig. 2.)

Time study is a management function. It should enjoy not less than equal status with the production manager or chief planning engineer. This is not to state that each member of the time study department should enjoy the same authority as these officials, but certainly the time study chief should be in a position where his point of view can carry authority.

NUMBERS REQUIRED

The correct number of employees in the time study department itself is naturally dependent upon the size of the factory or organization. This is obvious, but other factors have to be taken into account apart from mere numerical strength. The type of work, the number of operators engaged on direct production, the types of indirect worker, the scope of the time study department itself, and

whether its terms of reference include motion economy. All these, very naturally, have a bearing on the number that will be required to staff the time study department efficiently.

As a very general guide, it would not be an uneconomic standard to set if we assume that including the time study observers proper, the clerks, and the supervision of the department itself, seven people for the first thousand operators and three for every thousand above this minimum is a fair and desirable proportion.

It is assumed that time study will perform all the functions outlined in the previous chapter, and based on this the figure quoted is one that is likely to yield the highest return in proportion to the labour involved.

The qualities required of a time study observer present one of the most difficult questions to answer, principally because so many different trades require so many diverse types of training, and this factor must be the main guide. As it has been previously stated, tact is one of the foremost qualities and its absence negatives all other qualities. Certainly loyalty is another attribute, and if a start is made in analysing the qualities required in a time study observer it is rapidly seen that these qualities would make the perfect employee in whatever capacity that employee was likely to be engaged. However, here is a list. It is extremely improbable that the candidate will possess all the qualities mentioned. That would make the candidate too perfect! And in any case, perfection is an impossible attainment in anything or anybody.

QUALIFICATIONS

(*a*) **Mental Alertness.** Obviously the candidate should be quick-witted and observant. Mental alertness is necessary in order to be able to look out for and observe faults under study, to make rapid calculations, and possess the faculty of being able to obtain information from various sources.

(*b*) **A Mathematical Mind.** This is a normal expectation. If the candidate shows a tendency to be careless in calculation or lacks an elementary knowledge of mathematics, the task of checking rates and calculating bonus-potential will be beyond his immediate scope.

(*c*) **Engineering Background.** In the engineering industry the observer should preferably possess an engineering background; engineering training is not vitally necessary, but the possession of this will immeasurably aid in obtaining efficiency. Certainly the period of training in time study can be reduced if a knowledge of engineering is held by the candidate.

(*d*) **Fair Mindedness.** The time study observer is the link between *earnings* and *wages*. Rates affect the most important psychological reaction of all—namely, the pocket. Too high bonus means labour trouble; dissatisfaction caused by comparison and too low bonus earnings should be an anathema because it is associated with "sweated labour."

(*e*) **An Easy Approach.** This is essential to the smooth running of any organization. Personality enters into this to the *n*th degree. Shop stewards, labour, supervision, management, all will have to be contacted at some time or another, and the disagreeable man or the one lacking in vision will find it difficult to obtain co-operation.

(*f*) **A Strong Personality.** It will often be necessary to convince both operators and supervision that the earnings-potential forms the criterion. This is particularly true of repetitive work where familiarity and habit will decrease effort and increase output. It is vital to envisage future earnings in order to avoid such ridiculous bonuses as 100 per cent over long periods

(*g*) **Fundamental Honesty.** Stooping to subterfuge to secure acceptance of a rate destroys confidence and self-respect. In this section should be included a warning against "ambush timing" and "traps," both of which have given time study methods a bad report.

(*h*) **Fitness.** This is important. Physical well-being is necessary for the correct evaluation of speed and effort. Long studies involving standing in extremes of temperature throw a strain on the physique. Tendency to varicose veins or foot troubles detracts from efficiency.

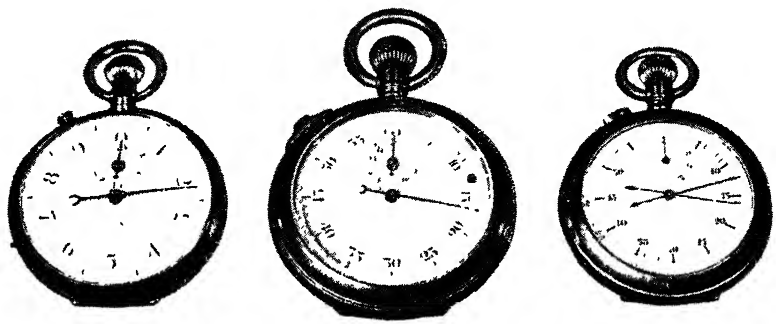
EQUIPMENT

Having decided that the department is to be staffed according to the needs of the factory as a whole, and that the personnel are to conform to a standard of behaviour and a code of ethics, what else is required? This is best answered by giving some details of the time study observer's working tools.

It is assumed that such equipment as may be required in addition to the following list will be covered, loosely perhaps, by the term "Office Furniture."

Watches. First, stop watches are an integral part of the time study observer's equipment. These must be accurate and a sufficient supply must be available not only to give each observer his own watch, to be regarded as his sole responsibility, but to provide a sufficient float to replace breakages, and there should still be enough to lend to other departments for such functions as cycle measurement and checking revolution counters.

In addition, the clerks, if they are to assist in the checking of overall times, will need watches. It is not considered desirable that the watches being used by the time study observer should also be used by the clerks, neither should they be lent The reason for this is very simple. All types of stop watches are operated by depressing a knob. This controls the action of the hand or hands and the time study observer, by constant usage, will adjust himself to the "feel" of this knob. Loaning out a watch means that this depressing action



(*A*) (*B*) (*C*)

FIG 3

(*A*) Decimal watch, fly-back type
(*B*) Fly-back type (seconds).
(*C*) Split-hand watch divided into 300ths part of a minute

will be affected, particularly if the loaning out process is likely to be recurrent. The time study observer will lose some of this "feel," which will react upon the acquired dexterity. Anything that detracts from the concentration of the study is to be avoided, and certainly an unaccustomed "feel" will consciously or unconsciously affect the observer during his study.

A reputable make of watch is essential. Accuracy is very necessary, and it is better to pay a high price for a good make than to run the risk of the watch varying in its clock mechanism. The above illustrations (Fig. 3) show the main types of watch being used in time study to-day

(*A*) This is the decimal watch. It records the time in decimal parts of a minute, and also records one minute on the completion of a circuit of the dial. This watch is operated by the small depressing button seen left of the knurled knob. This operates the fly-back action, but when the knurled knob itself is operated, this stops the watch; a second

pressure, and the hand continues to record. This takes the place of the slide that operates the "suspension" action described in *B*.

Its disadvantage is that it is not easily or comfortably held whilst studying; another disadvantage is that, because the recording is in decimals, it cannot easily be used for "proving" rates because of the difficulty the operator (and some charge-hands) will have in converting the decimal to English time.

The fact that the time is recorded in decimals is an advantage in those organizations which use the decimal system for the setting of rates and the computation of bonus, because calculations are rendered more easy.

(*B*) This is the most popular type. It is called a "fly-back" because when the knurled knob at the top is depressed, the hand flies back to normal or zero. The dial is divided into seconds, and one complete circuit of the dial records one minute. The small recording hand in the inserted dial at the top records the minutes run up to thirty. This is also cancelled by the application of the knob. Each second is subdivided into fifths of a second, so that the dial is actually divided into 300ths parts of a minute.

The slide shown on the left-hand side of the knob stops the watch at any desired reading. When the slide is released, the watch continues recording without cancellation having taken place.

One of the main advantages of this type of watch is that it renders "rate-proving" easy, since the operator or charge-hand querying a rate can see the overall time expressed in actual seconds, unlike the decimal watch shown in *A*.

(*C*) In *C* will be seen rather a special type of watch. This is used mainly for motion study, and it will be observed that it has a split hand. This is particularly valuable for the analysing of motions. Its dial is broken down into 300 parts of a minute, and the inner dial records up to thirty minutes.

On the dial will be seen a second set of figures, this time on the inner part of the 300 parts recording dial. This is, frankly, an adaptation purely as an economy measure, so that the watch can be used purely as a normal time-study watch should the occasion demand it.

This watch does not possess the "fly-back" action that is common to the others. It is known as a "three trip" watch, because three separate actions are required to operate the hands.

When the knob is depressed, the hands, both as one, start to record. Another pressure of the knob stops both hands, and yet another pressure will return the hands to zero.

The oval knob seen on the left separates the hands at any given moment, one hand recording the time so far taken, and the other continuing to run on. The knob is then used to stop this second hand and both are returned to zero as previously described.

The particular use to which this watch is put is more clearly demonstrated in the chapter on "Motion Analysis." (See page 158.)

Watches should not be allowed to run in between taking studies, but they should be allowed to run down overnight. This is to ensure that every morning they have to be wound, so that there can be no risk of the watch stopping during a study due to its becoming run down.

Watches should always have a safety-thong fixed to the watch ring; this can be of any material, such as pliant cord, leather, or thonging. It should be long enough to slip over the wrist and at the same time permit the watch to be comfortably held while studying. The provision of this safety-thong will prevent unfortunate accidents happening, and in a busy factory, particularly, there is the ever-present risk of somebody brushing by and so causing the watch to slip.

Slide Rule. Another part of the time study observer's equipment is the slide rule. This valuable little instrument permits the rapid evaluation and reconciliation of the rate. As is well known, its accuracy is limited; nevertheless, for rapid computation of rates its value cannot be over-estimated.

If the time study department is working in the engineering industry, then a knowledge of measuring instruments is necessary. It is not recommended that the personnel of the department should have their own micrometers and verniers, but they should have made available for their own use the standard gauges and instruments.

Inspection standards will need to be maintained, and one of the duties of the observer is to ensure that the parts being produced under study are conforming to inspection standards. Much time can be lost and the study rendered valueless by waiting until the run is completed before getting the standards checked. This will not obviate the necessity for an official inspection, the point is merely raised as a guide to saving time.

Study Board. Each time study observer will need a "study board." (See Fig 4.) Upon the study board will be clipped the observation sheet and its continuation. These observation sheets or study sheets can be set out to meet the particular needs of particular industries; in the main they carry such information as will prove of value for future reference.

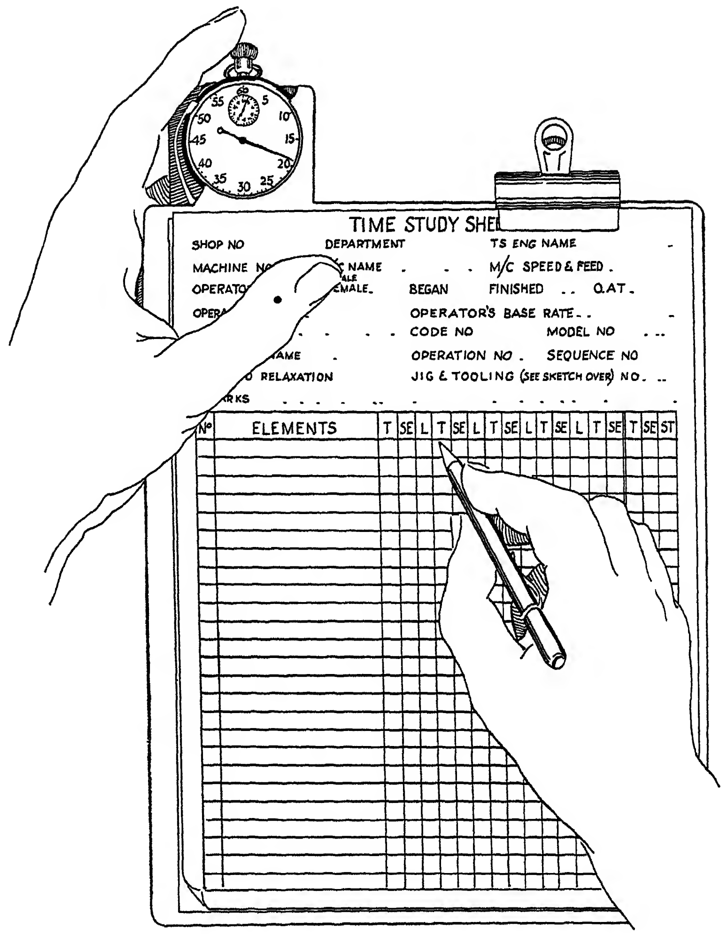
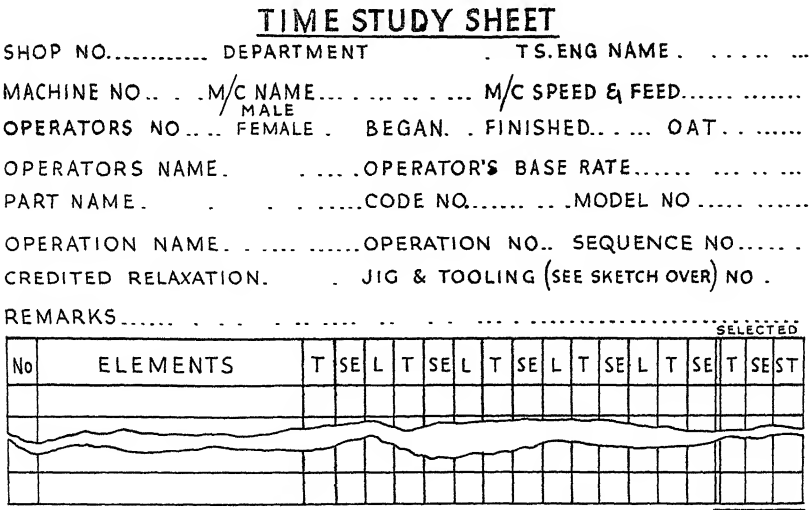


FIG 4

It will be observed that this sketch shows only one copy of the Time Study Sheet. Naturally the continuation sheets are clipped behind this top sheet so that the "turning over" process can be easily performed.

The need for such records cannot be too highly stressed. Supposing that the time study observation was lacking in detail, there would be no evidence in the future whereby checks could be made against the study; thus it would be impossible to prove that a method had altered or, what is more important, in the case of a



TIME STUDY SHEET

SHOP NO.......... DEPARTMENT . T.S.ENG NAME . ...

MACHINE NO.. . .M/C NAME.......... M/C SPEED & FEED............

OPERATORS NO.... MALE / FEMALE . BEGAN. . FINISHED...... OAT. ....

OPERATORS NAME. .....OPERATOR'S BASE RATE...... ....

PART NAME. . . . .CODE NO........ .MODEL NO ....

OPERATION NAME. ....OPERATION NO.. SEQUENCE NO..... .

CREDITED RELAXATION. . JIG & TOOLING (SEE SKETCH OVER) NO .

REMARKS......

No	ELEMENTS	T	SE	L	T	SE	L	T	SE	L	T	SE	L	T	SE	SELECTED T	SELECTED SE	ST

FIG 5 OBSERVER'S SHEET

The heading is filled in according to the inscriptions, the elements are written as comprehensively as required and provision is made for five recordings across the sheet Under "T" is written the time actually taken, under "SE" is written the observer's conception of the speed and effort value, under "L" is recorded any lost time due to non-operation demands It will be observed that this example is using the "Selection" method of reconciliation, for the final figure for which provision is made at the end under "ST," i e. Standard Times

claim for increase in time allowances, there would be no evidence upon which to base the extra allowance.

The need for accurate recording is important, but no less important is the collection of data.

Here is a brief description of the minimum needs in regard to the amount of paper work considered necessary for the efficient fulfilment of the functions of time study.

OBSERVER'S SHEET

This is the study sheet (Fig. 5). It will contain all the relevant information necessary for future reference. It provides a complete history of the operation and/or sequence of operations performed by

the operator under study. The sheet should carry the following information at least—

(1) Operator's name.
(2) Clock No.
(3) Shop name or number.
(4) Part name and/or number.
(5) Operation name and/or number.
(6) The parts and materials involved in the operation.
(7) The bench position.
(8) The time of the day.
(9) The time taken over the study.
(10) The overall time of the operation(s) itself.
(11) The number produced under study.
(12) Position of service (i.e. main stock) where the parts came from and where they are to go to.
(13) Inspection standards and tolerances.
(14) Whether all the parts under study passed inspection and what percentage of rejects.
(15) Class of material.
(16) If tools are used, their description.
(17) If a machine is used, its description and number.
(18) If cutting tools are used, the type of jig, whether manual or mechanical.
(19) Details of load and unload.
(20) Details of gravity bins or tote pans.
(21) Method of transport from machine or bench.
(22) Frequency of supply and removal.
(23) Lighting conditions.
(24) Hazards.
(25) Degree of fatigue.
(26) Existing rate or target.
(27) Whether the study is check or re-study, and concise details of operation.

This latter must always be included. Even if the job has been motion studied and the details of the operation correctly written up during the investigation, nevertheless slight alterations inevitably creep in and the operator idiosyncrasy invariably accounts for variation. This may represent quite a considerable difference in the time allowance, and if the time study observer has been responsible for the motion study then it also affords him an opportunity of checking the efficacy of that study.

The following illustrations give an idea of one of these study sheets written up.

CONTINUATION SHEET

This (Fig. 6) will be pinned immediately behind the study sheet, and will carry only the details of the timing and the rating efficiency. It is not necessary to repeat the actual operation elements on this sheet unless the operation is so complicated that the memory factor will be unreliable.

TIME STUDY CONTINUATION SHEET

NO	ELEMENTS	T	SE	L	T	SE	L	T	SE	L	T	SE	L	T	SE	L	T	SE	ST

FIG 6

This is a replica of the Time Study Sheet, except that it does not carry the particulars contained on the heading of the Time Study Sheet.

STUDY STANDARDS SHEET

This (Fig. 7) is used to give the operator an accurate picture of the job as when studied. It also contains the speeds, feeds, and rates. Its adoption can be extremely valuable, because very often when operators change over jobs sufficient details are not usually passed to enable the relieving operator to do the job in the same manner and under the same conditions as those in which the job was studied, with the result that the second operator sometimes finds it difficult to produce the same amount of work as the previous one. The charge-hand or foreman, too, will find it useful, since he can refer to it to check whether the job is still being done in the same way. It saves time because obviously charge-hands and foremen cannot carry all the data in their heads, and it is easy to check with a glance whether the operator is making schedule.

RATE ADVICE

Some method of rate advice is necessary. This can take several forms and some are discussed here.

STUDY STANDARDS

PART NAME				PART NO.
OPERATION NAME				OP. NO.
MACHINE	NO	FEED	SPEED	MAT.
RATE	PCS/ HOUR	HRS/ 100	BONUS RATE	PCS/ HOUR
NO. OF TIME STUDY		DATE TAKEN		BY
DESCRIPTION OF ELEMENTS				

FIG 7 STUDY STANDARDS SHEET

This is an example of a ready means of conveying information to the shop concerning the job It will contain all the relevant information regarding machining, etc , and, in addition, will be a replica of the time study write-up, so that the job will always be done the same way.

(*a*) In Chapter V, page 55, it will be shown that the best type of rate advice is that which indicates the time allowed for the job. The schedule having been worked out, the time study department reconcile this total with the rate and so a time can be given for the completion of the job, thus removing any risk of ambiguity. The form for this information can be designed to meet the requirements of the firm concerned. Mainly it takes the shape of a "job sheet" and follows down with the material. On it are contained—

(1) Name of part.
(2) Code number (if any).
(3) Details of the operation to be performed.
(4) Time allowed for completion of job.
(5) Number of parts to be operated.
(6) Inspection standard, i e. tolerance if machining operation.
(7) Room for inspector's signature, and destination after being passed, whether to stores or to another operation.

Obviously the ideal situation would be to have the whole sequence of operations listed, together with the time allowed for each operation. The difficulty about this is that the first operator would have

to wait until the last operation had been performed before being paid for the work done. and the stock control office would have no knowledge of the progress of the job. Passing the job into stores

SHOP RATE APPLICATION.

T.S.E.______ REF No______

CODE No______	OP No______	M/C No______
OP DIS.______		M/C NAME ______
______		M/C FEED SPEED ______
RATE IN "A"s	RATE AT BONUS SPEED	ISSUE DATE.______
______	______	EFFECTIVE DATE ______

FIG 8 SHOP RATE APPLICATION

This is another Study Standards Sheet which is affixed to the machine or bench, and indicates to the operator the speed at which he has to work in order to (*a*) earn his base rate, (*b*) make bonus rate It will be seen that there are two dates shown, viz issue date and effective date This is because the issue date is not necessarily the date at which the rate becomes effective

after each operation has been performed does mean that the above two objections are removed.

Another means of advising the rate is to have a Shop Rate

PART NAME LYNCH PIN	SCHEDULE 35000	COPIES PROD OFFICE - CONTROL TIME STUDY - WAGES
PART No 16380	WEEKLY PROD 7000	M/C SHOP - ASS SHOP - PLATING SHOP
	START 5-7 43	PROGRESS - INSPECTION

OP No	OPERATION NAME	M/C NAME	M/C No	RATE	OP RATE	SET UP	INSP	TRS ALL	TOOL NUMBERS OR REFERENCE
381	TURN - FACE - RECESS PART - OFF	CAPSTAN	C	12 5	1/5d	25	10%	18	STD 16724 16723 · 16720 · 16720
382	REVERSE FACE	—Do—	D	14 8	1/5d	25	10%	18	STD 1428
383	MILL		H	22	1/4d	12	10%	18	G 1920

FIG 9 JOB SHEET

This Job Sheet is one method of incorporating all the relevant information regarding the progress of parts through a shop, together with the time values Its main advantage lies in the fact that all the information is contained on one sheet so that the costing is made comparatively easy

Application Card. This is usually made in triplicate. (See Fig. 8.) One copy goes to the foreman of the shop and one copy to the wages office; the other copy is retained by time study department. This ensures that each department concerned with the payment of bonus is well aware of the rate.

The method by which the amount of bonus earned is recorded and used is referred to in greater detail on page 60.

The time study man is now equipped for the study of the job, and the next step is obviously the selection of the operator to be studied. This is no easy matter. The operator to be studied may be one of a group of people all doing the same task or even may be the only one for that task. Again, it is possible (and sometimes desirable) that the study is to be taken in a laboratory or "mock-up room." In which case the conditions surrounding the job will probably be ideal, thus setting up conditions that will bear little relation to the job when it goes down into the shop. These points will have to be watched. The actual selection of the operator depends upon the circumstances. If the operator is unskilled or unsuited to the job, even if the operator happens to be the only one available, it is wiser to avoid setting a rate. Operators can be classified as follows—

OPERATOR CLASSIFICATION

(*a*) **Poor.** The poor operator may be subdivided into two classes. The first is based on the fact that the operator is unskilled, or is a bad worker, and shows no interest in the job, and the second is the type of operator who is acting from a sense of "self-protection." If the operator thinks that to work slowly is to get an easy rate, then the self-interest becomes the dominant motive. This is easily detected. The operator will show a measure of skill, will even on occasions under study produce some bursts of speed, but the overall result will be an extended time. It is shown up by the operator spending a considerable amount of time obtaining material; he will make out that the job is difficult; he will try to lengthen the process of examining; he will over-inspect or gauge too often; he will seize every opportunity to slow the job down. If a machine is used, the machine will appear to go wrong and have to be adjusted. If the operation is assembly, conditions which have given perfect satisfaction will suddenly acquire a nuisance value. Lighting will be poor, seating uncomfortable, and so on.

There is little one can do about this type of operator. For the unskilled operator a system of training can be recommended. For the obstructionist, a straight talk might help, but usually the suspicion is so deeply ingrained in the operator's character that a tight rate is inevitable, that it is almost impossible to penetrate the crust of prejudice.

(*b*) **Fair.** The fair operator will give some co-operation but not much. Indifference to the time study observer is apparent. Advice or requests will be received grudgingly, a reasonable speed of working will be observed, and a degree of skill compatible with the experience

of the operator will be shown. Actual antagonism will be absent but so will actual enthusiasm.

Sometimes a talk with the operator will help to remove bias. It must be borne in mind that when the fair operator is normally a good operator, then sometimes domestic trouble, temporary ill-health, or even a current dispute with supervision causes the apathetic attitude. Steps should be taken to ensure that none of these represents the cause before the operator is rated.

(*c*) **Good.** A good operator is one that works well, takes an interest in the job, is able and willing to accept advice, and has attained a high degree of skill. Speed is well in evidence and the disposition of the operator one of cheerfulness This is the type of operator which makes rating a comparatively simple task.

(*d*) **Excellent.** This type of operator is one that works diligently, has a good turn of speed, is enthusiastic, is highly skilled. There is a tendency with this type to work faster under study than when unobserved, being naturally co-operative and having an interest in the job. There is the risk that the time study observer will over-rate this type of operator.

It is obvious that the type of operator has a bearing on the study. If the operator makes a lot of mistakes, or has an inordinately high percentage of rejects, the study is useless. The fast and skilled operator too presents a danger. It will be seen later on that the watch readings of the time taken are tied to the rating efficiency in order to set a standard. Time study observers, being human, are apt to over-rate the excellent type of operator with the result that the rate will be a loose one. Such tendencies must be guarded against, and the best protection is to study one type and then ask for a re-study on another type; the resulting standards will throw up any tendency of over- or under-rating.

A CODE OF CONDUCT

There are ethics in time study as there are in most professions. Time study observers should never permit themselves to be placed in the position of checking a colleague's rate unless he is aware of it, in which case all the relevant details should be discussed and, if there is any variation, he would be able to take a re-check himself. The reason for this is obvious. Some classes of supervision, knowing nothing of the methods of rating, are apt to query rates and try to acquire a different result by subterfuge. If this occurs, clearly there is plenty of scope for the suppression of vital information which would affect the net result. The actual standard might be the same,

but the answer might well be a different one due to a different set of circumstances. A frank interchange of information with each other will prevent time study men being faced with embarrassment.

Another point to remember is that, as a rule, time studies should not be made without the knowledge of the floor supervision. Indeed this is a dangerous habit upon which to embark. Supervision should be afforded the courtesies due to their rank, and since they have to handle the labour, it is only fair to them that they are fully cognizant with the time study programme set for their floor or department.

When taking studies, time study men should remember that they are representatives of management, and should engage in no practice likely to lower its prestige. Smoking while studying is bad form; so too is lounging or leaning casually against the work bench.

Time study observers should avoid being inveigled into trying to perform the task themselves. They should be fully aware of the pitfalls that lie in the path of trying to "prove" rate by demonstration. This is entirely different from the demonstration needful in tuition of a change of method. Acquired skill cannot be demonstrated if the time study observer is basing his technique on a few observations. If practice is necessary then it should be confined to the laboratory and not done on the floor.

Where there are rules to be obeyed, it behoves the time study observer to obey them. If an example is set, there is no cause for criticism, and time study itself presents a sufficiently large target for the operator without adding personal inefficiencies to it!

While the time study observer will be able to offer suggestions regarding the method of doing the job, nevertheless he should be warned against trying to exert discipline. If an operator gives trouble or is not doing the job as it should be done, the proper channel for any criticism is via the supervision. If satisfaction cannot be obtained, then it is a matter for the head of the time study department to handle.

CHAPTER IV

RATING

One of the most important parts of the time study observer's equipment is his rating efficiency. Rating is a method whereby the different speeds of the operators under study are converted to a common denominator. It is all very well taking time recordings, but if the speeds of the operators vary, then the times recorded vary too. True, the breakdown to a common denominator upon which to fix a rate or assess a normal working speed can be done by averages, but this, in the main, is an unsatisfactory system, since it involves selecting a time value that is somewhere in between the two extremes. The obvious difficulty is to select the times, since it naturally follows that as the speeds of the operators vary, so, too, must the average or the selected time. This point is illustrated as follows: Assume two operators, "A" and "B." They are both performing exactly the same functions, but over a series of readings the following times are recorded—

"A" (in seconds)	"B" (in seconds)
16	12
20	10
16	11
12	15
18	9
22	12
20	13
22	12
16	17

The average for "A" will be 18·0 seconds
The average for "B" will be 12·33 seconds

This shows a marked discrepancy in speed. Suppose the selective method is adopted. This is based on the theory that the lowest and the highest should be ignored; the lowest because that is a speed upon which an operator will be expected actually to make bonus; the highest because that shows the operator was clumsy, unskilful, or even deliberately slowing down.

So this would give for "A". Disregard 12, 20, and 22. This leaves 16 and 18. So the rate would be between these two, i.e. 17 seconds.

For "B," this would show the following: Disregard 9, 10, 15, and 17. This leaves 11, 12, and 13. So that the rate would work out at the mean of 11, 12, and 13. So this gives 12 seconds.

These times are actual times during a normal run in a light engineering factory. Considering the fact that the job is exactly the same, it will be seen that there is a wide variation between 17 seconds for "A" and 12 seconds for "B," and the observer relying either upon averages or selections will still be faced with the decision as to which time to accept

Was "A" particularly slow or unskilled?

Was "B" particularly fast or skilled?

If the average times were accepted as the base rate then this would react unfavourably to both operators. In "A" it is seen that the average is 18 seconds; suppose this was accepted, it would be found that the operator would only just make bonus because the speed is an average in any case, and it is unlikely that the operator would speed up because of the impression that the average is an optimum in any event.

The fact that the second operator "B" has reduced the average time is unimportant; the mental approach to the job shown by the operator is the guide If the operator knew that rating was employed, at least the assumption is there that this rate is applicable to all operators, whereas since the average is used as a basis, it naturally follows that the operator's own average has been used as a guide, thus throwing the onus of making better speed on *that* operator who is already convinced that the maximum average speed has been reached.

RATING AS A COMMON DENOMINATOR

Rating will avoid these discrepancies, and will level out the speeds of these two operators and any other operators that will follow on this job, so that a fair time is set upon which can be based a just and equitable rate.

Rating is the "normalizing" of the job under study, and can be taught only by practical demonstration. Theory *will* help, but the basis of rating efficiency is essentially practice. In the case described above rating would have taken care of the abnormal speed of "B" and the subnormal speed of "A." So that a result would have been produced by which "B," by virtue of the greater speed, would have made bonus, while "A" would have had to work harder or faster to attain the same bonus enjoyed by "B."

To analyse rating, the observer must first master the elements

of cycle timing with a stop watch. Stop watch accuracy is necessary and complete familiarity with a watch is essential before the brain can be freed to deal with the mechanics of rating.

Rating is based on a system of points. So many points are given for so much speed and effort. This effort factor must be borne in mind when the rating is being done. The points value is usually a 60, for no other reason than that there are sixty seconds in a minute and it is an easy way of reconciling the time taken with the time that should be taken.

Sixty is the base or flat. In other words, if the operator is an average operator, of average skill, and putting into the job an average amount of effort and concentration, and the amount of speed that is shown is also average, then whatever actual time would be clocked, this would be reconciled at 60. If the operator was working at 25 per cent greater speed with the corresponding greater effort, then this would be rated at 75 (i.e. 60 + 25 per cent = 75). Conversely, if the operator was working at 25 per cent less speed than the average or normal, then the rating would be 45 (i.e. 60 — 25 per cent = 45).

It will be seen that there will be difficulty in assessing what is normal speed, since this is the speed that has to be found in order to establish the standard.

AN EXAMPLE

This must be demonstrated, but in order to assist the reader to understand this more clearly, here is an analogy. Suppose a bricklayer's labourer had to wheel a barrow. It is known that the normal speed of a person walking along a road, unhampered by any sort of load, is three miles an hour. Is it expected the labourer should push a wheelbarrow at the same speed as a "normal"? Of course not. So that if he were progressing at the rate of three miles per hour he would be exceeding "normal," and his rating would be higher than a 60.

Here is a further case. Supposing that the wheelbarrow was loaded with gravel, and the labourer now pushed his barrow at three miles an hour, clearly this would deserve an even higher rating, solely because he now has to exert more effort. Pursuing this case and assuming that the man has to push his barrow along a narrow gantry, say 15 inches wide and 3 feet above the ground, an element of skill in keeping the barrow on the gantry has been added, and so the rating would be even higher.

The one weak link in this example is the actual time taken to do

the pushing of the barrow when it is empty. If the observer was doing this study for the first time, he would have to assure himself of an average or normal time for the pushing of the unladen barrow.

Naturally, in most trades in which the observer specializes, this does not present very much difficulty, because the observer will be conversant with the general speed necessary to perform most operations. The difficulty is experienced only by the newcomer to the trade, and this is where practice and careful training are indicated. In Chapter VII will be found some indication how this assessment can be made.

Some organizations do not use 60 as a base rating, but prefer the rating of 100, so that the increase or decrease is expressed in percentage terms. This is of small importance, since it is the actual rating which maters.

The reconciliation is simple. Analysing the two operators shown on page 35, "A" and "B."

A's rating would appear something like this—

"A"

Time in seconds	Rating based on a 60 "Normal"
16	45
20	36
16	45
12	60
18	40
22	32
20	36
22	32
16	45

"Reconcile" these figures by taking the average time (reconciling being to divide the sum by 60 to find the normal or flat time). E.g

$$\frac{162}{9} = 18 \text{ seconds},$$

and the average rating:

$$\frac{371}{9} = 41{\cdot}22, \therefore \frac{18 \times 41{\cdot}22}{60} = 12{\cdot}37 \text{ normal seconds.}$$

In the examples 60 *is taken as the base rating;* 100 *could have been used, but in that case the dividing factor would have been* 100 *also.*

"B"

Time in seconds	Rating based on a 60 "Normal"
12	60
10	72
11	66
15	48
9	80
12	60
13	55
12	60
17	42

Reconciling:

$$\frac{111}{9} = 12{\cdot}33 \text{ seconds,}$$

and the average rating:

$$\frac{543}{9} = 60{\cdot}33, \therefore \frac{12{\cdot}33 \times 60{\cdot}33}{60} = 12{\cdot}39 \text{ normal seconds.}$$

So it will be seen that instead of having two averages, "A" 18 seconds and "B" 12·33 seconds, there is now a "normal" time which for practical purposes is the same.

Of course, an extremely high degree of skill is required to rate as accurately as these examples, and it is customary in some organizations not to rate below 60 This is because it will be almost impossible for such a poor operator as "A" to make bonus anyway.

The alternative is either to treat such an operator as a learner or make a special allowance (See Chapter VI), or have the operator properly trained.

HANDLING COMPLICATES WORK RATING

Of course, the rating is not going to be as straightforward as this example. All sorts of complications creep in under study, such as the frequency of the load and unload. It may be that jig loading is for four off or even; in the case of a Bakelite tool, the loading and unloading may be eight off. Then again, different conditions will require different treatment. This is particularly true in the case of a machine-controlled cycle. One can rate the physical factors of load and unload, but the rating that is to be applied in the case of machine-controlled movement quite clearly cannot be the same as that for those cycles or movements which are controlled by the operator.

Where assemblies are on a conveyor system, it is very necessary

that the operator keeps up with the speed of the belt; this is also true in the case of some milling operations, where the tool speed is fixed and the return travel is automatic. Then there is the assessment to be considered where the automatic lathes are operated, not by one operator to each machine, but one operator to a battery.

As a general rule, the tool designer or the production manager will indicate the speed at which he wants machines set. Then if the normal physical motions are studied in order to rate them, and the actual machine control cycle is rated at 80 or 85 (60 being the normal), this will give the operator an opportunity of making maximum bonus compatible with the established principle of the firm concerned.

This latter is important. It may be that the established bonus potential is 25 per cent, in which case the machine rating will have to be 72. It will be observed that in both the cases quoted, the full rating has not been given, i e. 85 on an expectation of 50 per cent bonus as against 90; 72 on a 25 per cent bonus expectation as against 75. This is done for a special reason.

If the rating was at full measure, and the allowances were added for fatigue and other conditions, clearly the operator who works over and above the fatigue allowances will be taking the extra bonus There is no cogent reason for assuming that this is necessarily wrong. But since fatigue allowances are given, then it must be assumed that they will be taken as compensating factors and not merely an inducement to work on against the feeling of tiredness.

ALLOWANCES FOR FATIGUE

Fatigue allowances are calculated, as a rule, on established scales. It will be apparent to the reader that, as the work progresses, so a certain amount of fatigue will be engendered. Therefore, in order to compensate for this, a special allowance is added to the time allowed in order that, as the operator's speed slows through tiredness, the rate of expected bonus will still be made.

It would be logical to expect that the allowance should only be given when the fatigue becomes a fact, i.e. towards the end of a shift. However, as this would be a cumbersome thing to calculate, the fatigue allowance needs to be added to the time allowed, so that during the early part of the shift the operator is actually making more bonus than the expected yield. This is counterbalanced by the fact that as the post-middle of the shift comes on, so the speed of the workers will diminish. Actually, it is a well-known fact that towards the end of a shift the speed of the operator increases; this

is mainly due to the stimulus of the thought of going home, and the fact that the operator is endeavouring to make up for lost time, if any.

Personal needs are an integral part of the allowance. It is fairly obvious that operators cannot be penalized for going to the cloak-rooms, providing that these visitations are kept within reasonable limits. The allowance will thus provide for the operator's bonus to be maintained. The figure that is customarily used is 5 per cent. Since the figure for personal needs is constant, whatever the fatigue allowance is, the addition of the 5 per cent will naturally be included

The fatigue allowance will vary between shop and shop. It might also vary between operators working in the same shop. An example of this is seen in Bakelite moulding. The operator is given one fatigue allowance; his labourer another. The difference is shown in the fact that the labourer is paid to expend his physical energy in labouring, while the machine operator is paid for his skill. In this case, the labourer will get a smaller fatigue allowance than the operator, although the former's work is undoubtedly more exhausting.

This is not arbitrary. Most organizations give the same allowance to both; but while this is the method that eases the conscience of the management, the fact that the labourer expends more physical energy does not alter the fact that the operator has the responsibility of ensuring that the cure time is right, and that the tool is functioning properly, and therefore concentration is higher.

In Fig. 10 will be seen a specimen chart showing the varying fatigue allowances. It must be appreciated that these allow for personal needs, so that if this chart were adopted it would be unnecessary to add 5 per cent, or whatever the agreed figure happened to be, to the figures quoted.

RELAXATION

Mention has been made of relaxation factors. In the time studies, an agreed allowance is added to compensate for the loss of energy caused by the work involved There are other compensatory factors, however, that have to be taken into consideration. Breaks are usually arranged at certain times during the day for the purpose of allowing the operators to refresh themselves. Invariably there are three recognized breaks: one during the morning, one during the afternoon, and the main midday break. If overtime is being worked, then it is customary to give yet another break. There have been a number of large-scale

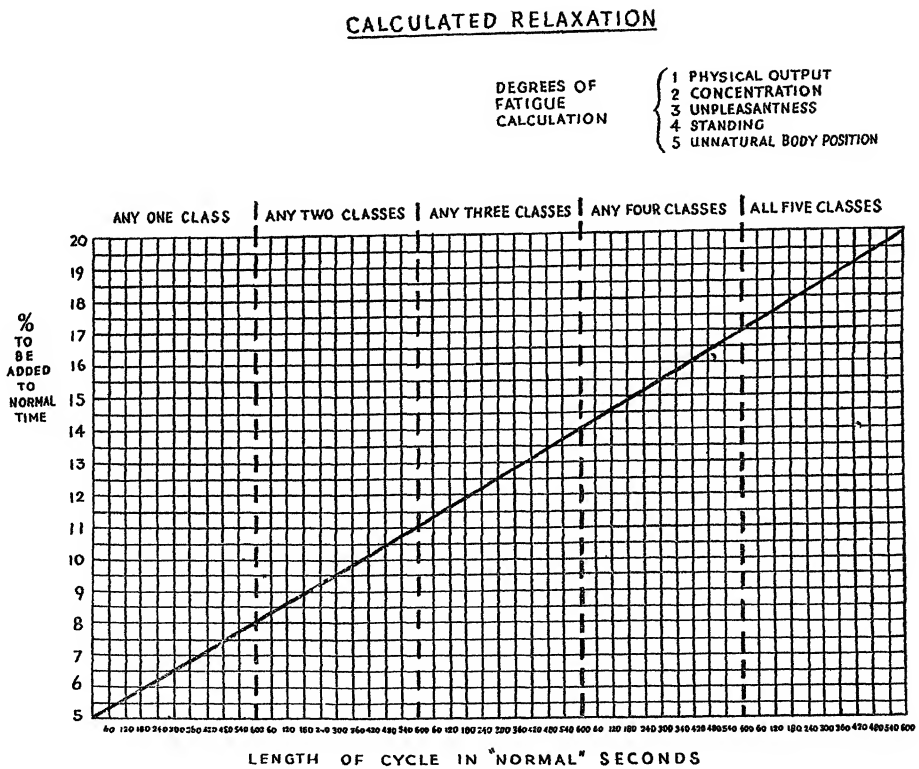


FIG 10

The above chart of calculated relaxation indicates in a very simple manner the *direct application* of fatigue allowances.

experiments to determine the most effective periods and the most effective time limits.

Theoretically, a break every hour should have the effect of pushing up production by breaking down the monotony of the job and permitting the recouping of energy. Practice, however, indicates that this is not necessarily the case; it seems that the regular break every hour is disliked by the majority of employees, because, they complain, it upsets the rhythm of their work There is a great deal to be said for this.

A fact emerges from researches made by the author, and that is that no output is *exactly* the same per hour, and that cycles occur when the output is higher, apparently without regard to the time of day.

The group of operators concerned were all girls, and the job was jig and mechanical assembly. There were two breaks—

(*a*) At 10 a.m. (*b*) At 4 p.m.

These, of course, were separate from lunch time, which was at 12 noon. Starting time was at 8 a.m., and normal finishing time at 6.30 p.m.

It will be seen that there are distinct peak periods, the output of which is never equalled by any other time. A feature of the graph (Fig. 10A) is that the time when output should be highest, due to the freshness of the operators, and after allowing them to settle down, i.e. from 9 a.m. to 10 a.m., falls far short of 2 p.m. to 3 p m. At both breaks tea was supplied from a trolly, and, if necessary, operators could order cakes and buns beforehand; most of them, however, chose to bring their own sandwiches. No restrictions were placed on the operators' movements during these periods; during the summer months they left the shop and sat outside on the grass; in the winter they grouped themselves according to friendships and general social requirements.

Controlling the Relaxation Factor. Relaxation can be taken in a variety of ways, but efficient relaxation is one that is controlled For example, operators will often seek opportunities for leaving the work benches, either for the purposes of using the cloakrooms or for obtaining supplies of materials The former reason is allowed for under the heading of "personal needs," usually to the extent of 5 per cent of the allowed times; the latter cannot be allowed for and should not be permitted to occur. However, when this frequently occurs, it is usually a symptom of boredom or distaste, and steps should be taken to remedy it. Boredom cannot normally or easily

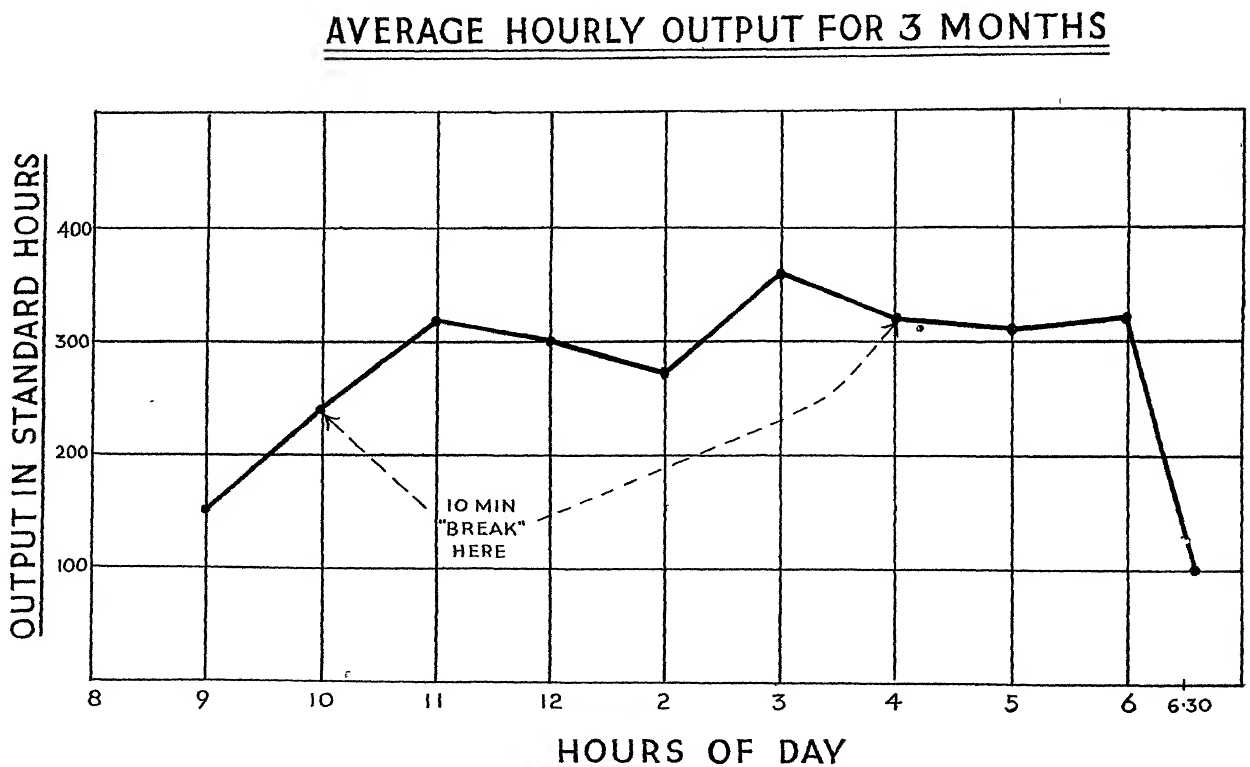

AVERAGE HOURLY OUTPUT FOR 3 MONTHS
OUTPUT IN STANDARD HOURS
400
300
200
100
10 MIN "BREAK" HERE
8
9
10
11
12
2
3
4
5
6
6·30
HOURS OF DAY

Fig. 10a

be overcome, although music played during the blank periods, i.e. between breaks, will help to curtail this tendency.

Operators on fatiguing jobs can be afforded relaxation by controlled cycles; the die-casting is one that springs readily to mind. In this case, a visit to the "blanket" room for the purpose of replacing fluids lost through sweat is one form of controlled relaxation. Certainly, the time study observer should pay a good deal of attention to the question of relaxation. He should consider the needs of the job; extremes of boredom require greater relaxation than those requiring a high degree of concentration, for although a high degree of concentration is probably more physically exhausting, the boredom is more insidious in its consumption of energy.

Where there is a machine-controlled cycle, in which the operator has relatively little to do, the relaxation factor can be considered under the "process allowance"; where, however, employment during a machine-controlled cycle is given, i.e. fettling or deburring, then an extra allowance will have to be given to reduce the fatigue caused by working at high pressure and divided attention occasioned by the need always to "race" the machine in the completion of the allotted tasks.

There is still another allowance that has to be given. This is called the "Process Allowance" or "P.A." for short. The reason for this is that in some operations, where the cycle time is machine-controlled, the operator will be idle for part of the time. This can either be considered as part of the relaxation, or it can be classed according to the need for strict concentration. In any case, for some part of the time the operator will not be physically working, so that as the bonus is controlled by the speed of the machine some extra allowance must be made.

Another example of this is seen on the assembly lines where for reasons of expediency the line is partly unbalanced. In this case, some operators will be held up because the previous operation is of a longer duration. Here, again, the operator will be idle. The time may be quite small, barely a minute in some cases where the time study department has done its job of balancing well. Even so, the fact that the operator cannot go faster because of the control over the speed so exercised, makes it customary to give the P.A. to compensate for it. This is so that the operator will not lose money by having to wait on the previous operator or the machine.

An example written up will be seen in Fig 11.

Before the rating can be applied it is necessary to analyse the

job to be studied. Even if the job has been motion-studied by the same observer, a fresh approach will have to be made from the point of view of taking a time study.

Rating efficiency will depend upon the rating of the individual elements that go to make the complete operation. For example, if the complete job is blanking on a 40-ton power press, it would be

Operator	Time allowed in seconds	P A (in sec)
1	34	Nil
2	36	Nil
3	40	Nil
4	32	8
5	34	Nil
6	29	5

N.B The P.A is given to the group, *not* to the operator Thus total group time = 205 secs P A allowance = 13 secs., so 6·5 per cent would be added to total time

(See also page 209)

FIG. 11

unwise to take an overall time and say that the operator's speed and effort is 75, i.e. 25 per cent above normal or flat, because the ancillary motions and the service operations would receive the value that might be either insufficient or too generous, so the actual job will have to be broken down into elements, and to do this the observer will spend some time on analysing the various elements that go to make the complete operation.

These elements will have to be easily timeable. The actual blanking element will probably be worth a second and, as this is impossible to time and rate and record all at the same moment, it will be necessary to write up the elements in cycles.

It is helpful if the observer always works to a preconceived plan, and here is a suggested plan covering the operation of blanking.

The observer will look for the source of the material; is it brought by a labourer? If so, when, and at what intervals? How does the operator let the labourer know when fresh material is required? Is the delivery based on the time cycle? (If it is, the cycle may well need alteration when the incentive scheme starts to exercise its power.) Who loads the material to the machine, operator or setter? Is the press automatically controlled, or is it foot-trip operated? What happens to the scrap? It is removed by the operator or the

labourer? If the former, at what intervals, and where does the operator put it, in bins or trucks? If the latter, is there a set time for removal? Who clears the receiving bin—the operator, setter, or labourer? At what intervals, and where does it go? What are the inspection standards? Is the line inspected at frequent intervals? Does the operator check with a gauge? If so, at what intervals or with what frequency?

These questions give a definite lead and remove the risk of missing an element that might have a bearing on the job. It is assumed that the operator in this case will not be setting the machine, but if it were a setter-operator, then an allowance must be given for setting, and this should be based on a schedule. Clearly it will take as much time to set for 5000 as it will for 50, and the setting time therefore cannot be based on a percentage of the total produced, since it is the aim of the observer to set a rate in order that the time allowed may be predetermined.

The cycles for timing for the above will probably be based on—

(*a*) Loading into machine by operator.

Formula is.

$$\frac{\text{Time taken} \times \text{rating}}{60} - \text{Number of blanks from each strip.}$$

(*b*) Trip-operate machine (say seven trips for a cycle).

Formula is:

$$\frac{\text{Time taken} \times \text{rating}}{60} \div \text{Number of trips.}$$

(*c*) Gauge. Grasp gauge, bend and pick up part, gauge, drop part back, aside gauge.

Formula is:

$$\frac{\text{Time taken} \times \text{rating}}{60} \div \text{Frequency (i.e. one in 30).}$$

(*d*) Fatigue and personal allowances.

If the setter-operator is responsible for setting up the piercing tool, then an adequate allowance must be made in addition. It will be readily appreciated that it is impossible for this time to be included in the rate because of the varying numbers involved. For instance, if the rate worked out at 300 pieces per hour and the actual setting took 20 minutes, what percentage would be added? Clearly,

if the time allowed is to be a constant one, that is, the same number of pieces will always be produced every time the machine is set up, then the percentage addition is easy; however, few jobs lend themselves to a constant factor. There are two alternative ways out of this difficulty—

(1) To ask the setter-operator to clock out each time he sets the machine.

(2) To average out the setting time for all the machines and to make the percentage effective over a week's work.

Both of these have weaknesses. In (1) it will be seen that the setter-operator will be penalized because he would receive day-work rate only for the period he is not actually producing parts, and, further, this setting operation can be used to show a higher percentage of bonus earnings. The setter-operator could book out for 30 minutes, whereas the job might take only 20 minutes, and for the remaining 10 minutes he could be actually producing parts which would not be debited against his time taken.

In (2) averaging out, apart from taking a lot of time in compilation, reacts unfavourably to the operator-setter. But, on the whole, not so unfavourably as in (1).

The ideal, it seems, would be to pay the setter-operator an increased hourly rate to compensate for the extra responsibility and to keep a strict check on the times booked out against setting. This can be done by having an inspector initial the clock card at the same time as the approval is given for the "first off" on the test for inspection standards.

The question of the setter's bonus will be dealt with separately under the heading of "indirect." Special qualifying bonus could always be given in order that setters may be interested in the shop incentive scheme as a whole.

The breaking down of elements will follow a similar treatment whatever the job. Some difficulty is experienced in the separation of the elements and the recognition of the time cycle in the assembly shops. If the job has not been motion-studied, then it becomes the time study observer's responsibility to ensure that the job is being done in the best possible manner before he attempts to make a time study.

If tools are being used then this usually gives a clear guide to the breaking down of a job. In those cases where no tools are being used, it behoves the time study observer to pay meticulous attention to the timing, for it is in these operations that the true sequence can be so easily lost.

CHAPTER V

TAKING THE TIME STUDY

THE mechanics of studying involve much thought. The observer will have checked that the conditions surrounding the job are in keeping with the established policy of the firm.

As a guide, the following list sets out the relative classifications which govern nearly all studies—

THE COMPONENT

(*a*) Is the batch representative, i e. will there be any variation between part and part?
(*b*) Have inspection standards been agreed to?
(*c*) Is the operation being performed necessary?
(*d*) Any hazards, e.g. delicacy of part necessitating special care?

THE OPERATION

(*a*) Is the job on the right machine?
(*b*) Can the set-up be standardized? Or improved?
(*c*) Is operation in right sequence? Can it be amalgamated?
(*d*) Feeds and speeds Are these correct? What checks can be made?
(*e*) Are tote pans in correct position?
(*f*) Trucking Service labour or operator responsible?
(*g*) Is machine adequately guarded? No hazards?
(*h*) Check lighting and seating

THE OPERATOR

(*a*) Is operator sufficiently skilled?
(*b*) Is operator keeping to proper sequence?
(*c*) Is operator working at fair speed? If not, note cause.
(*d*) Does operator know inspection tolerance?
(*e*) If strength is required, will operator be able to perform the task within the physical capacity?
(*f*) Does operator do own setting? Trucking?
(*g*) If protective clothing is called for, is operator properly equipped?
(*h*) Does job indicate extra fatigue allowance? Give reasons.

INSPECTION

(*a*) Has first part off been approved? Specimen kept?
(*b*) Is operator to do own gauging? If so, is gauge available?
(*c*) Inspection standards checking with drawing?
(*d*) What is the frequency of inspection? State percentage.

It is advisable to watch several parts through the complete operations in order to determine the local conditions. It might be that an unnecessary amount of time is spent on selecting parts, or that the reach is excessive. If this occurs during the study there is

danger that these "foreign" elements will be included in the time value, and since the aim of time study is to obtain the greatest possible efficiency for the job, this inclusion of foreign elements would detract from any such efficiency.

Before actually commencing the study, the observer will write up his elements This should be done in a concise manner yet must embrace all the relevant details.

EXAMPLE

1. Away gauge (R/H) and up lock key (L/H) Si.op.
2. Unlock, aside key.
3. Remove casting and lay to side (L).
4. Up casting (R) and locate, true.
5. Up lock key and lock
6. Aside lock key (L/H) and start machine (R/H) Si op.
7. Advance turret to stop. One tool, drill
8. Back turret, turn and advance to stop Two tool, drill.
9. Back turret, turn and advance to stop Three tool, ream.
10. Up cross slide and face to stop.
11. Up cross slide and recess to stop.
12. Stop machine (R/H), swing aside sud pipe (L/H) Si op. Up blow gun and remove swarf (R/H)
13. Away gun, up gauges (2) (L/H) transfer plug to (R/H) and gauge.
14. Aside plug R transfer depth gauge to R. and gauge
15 Away gauge R. and up lock key L.

It will be seen from above operational sequence that the elements are broken down into easily recognizable operations. Each one is clearly defined and thus permits the greatest accuracy for time recording. The abbreviations used are for time-saving during the write-up of the elements. The elements are numbered so that on the continuation sheet it should be unnecessary to rewrite the elements. Unless, of course, the job is so complicated and of such long duration that it will be impossible to remember them on the continuation cycles.

"Si.op" is used on three occasions. This is to indicate that the two operations noted were performed simultaneously, and thus prevents claims later on being admitted where the operations are performed separately. In this connexion it is up to the observer to indicate to the operator where such simultaneous operations can be so performed.

Here is a list of common abbreviations used in time study practice—

Up	. .	to pick up.
L/h	. .	left hand.
R/h	. .	right hand.

Ft . .	foot
As R . .	aside right
As L .	aside left
M/c	machine
Tl . .	tool
Loce . .	locate
Lok	lock
H/d . .	hand driver
R/d	rachet driver
Y/d .	Yankee driver
Des Tl . .	Desouter tool (always quote tool).
Flex/gr .	flexible tool for grinding
Flex/p . .	flexible tool for polishing, etc.
Flex/c . .	flexible tool for cleaning, etc.
Po .	polishing (state/mop for buffing). (/em for cleaning)
Tra . .	transport.
Trk .	truck
Lod . .	load
Ulod . .	unload
Sel .	select
Vis/Sel	visual inspection of selected component
Gl/Ins . .	glance inspection of selected component.

Naturally, observers will follow current practice at each particular firm, but, in the main, the above abbreviations are those which are in common use.

The example quoted on page 50 is a fairly easy one to record. Because the job is a machining operation, it follows that the future developments of the job will be limited. Of course, if the removal of the swarf was done by hand-brush, then at some future date when compressed air was introduced, the rate might need to be altered, but where refinements such as this one are already in being, the write-up of the elements is a simple matter and very easily checked.

On assembly work, the need to write up a study clearly and embracing all details is apparent. It is on assembly that the greatest number of changes can take place. Machining is very much the same wherever one works, but the physical act of assembling is one that is constantly changing, hence the need for scrupulous detail.

Here is an example of an assembly operation, written up with a view to guarding against changes taking place without being able to establish proof of a change.

OPERATION Assembly of a coil unit
WORKSITE 14 ft. from end of bench 3rd operator Individual lighting.
BENCH LAY-OUT. Radial bin. 17 in from edge of bench 6 cavity container
Each cavity scooped for easy location Cavities numbered 1 to 6, reading from left to right.

TOOLS. Small hand screwdriver (magnetized). Yankee 4 b.a.
Stanelco soldering unit Cantilever action for top carbon, foot operated. Cored solder on reel behind jig
Tote pan on left, supply bin on right Jig on worksite under solder unit. Jig has two holes bored to take body of wires
Operation. Locate two wires through coil unit, solder on two terminal tags. Screws and shakeproof washers to fix tags to base
Study Analysis. Sketch for this will be seen on page 168.

ELEMENT	DESCRIPTION
1.	Up part from right and site on jig, with "U" gap over bottom carbon of solder unit.
2.	Up two wires from containers 3 and 4, R and L/Hds Si.op. Locate in two apertures in part, allow body of wires to reach bottom of holes.
3	Up two tags (cavities 1 and 6) R and L/Hds. Si.op Locate on top of two exposed wire ends
4	Operate Stanelco unit by foot pedal, pull forward length of solder (cored), and solder on two tags Release solder (reel is spring-loaded)
5	Up 1 × 4 b.a screw R/h from cavity 5. Up S P washer from cavity 2 L/h and bring together. Si op Transfer to L/h. Up small driver R/h and seize screw with magnetic point. Locate direct to hole on left in base, and locate with ½ turn Retain driver in palm of R/h
6	Repeat as above, except driver is already up. Aside driver to right.
7.	Up Yankee R/h and locate head in screw, drive two screws, and tighten with last ½ turn rigid locking action Aside Yankee to position behind jig, R/h aside part from jig to left Si op.

It will be seen that this is a comprehensive write-up It needs to be. For assembly work there are so many variations within the control of the operator that it may well be possible for the operator to make a claim later for an extra allowance. If there is not a comprehensive write-up of the operations, it will be difficult to prove that the job has not been altered.

Thus the write-up of the elements is performed.

The times for these elements and the rating will be taken after the observer is fully satisfied that the job has been completely covered in all its aspects.

Naturally, the timing methods depend on the type of watch being used (although the rating value is the same). It has been shown that there are at least two types of watch in use: the fly-back recording time in minutes and fifths of a second, and the decimal watch recording in decimal parts of a minute. The use of this watch, which is the "three-trip type," is confined to "continuous reading."

TAKING A TIME STUDY

To take the actual study, the observer should be in a position where he can obtain a clear view of the operation, watch the ancillary movements such as picking up and placing aside of the part, be able to observe the operator's actual movements, and at the same time be able to look at his watch, record the time taken, and do the rating. This co-ordinated series of movements and observations requires a great deal of practice.

CONTINUOUS READING METHOD.

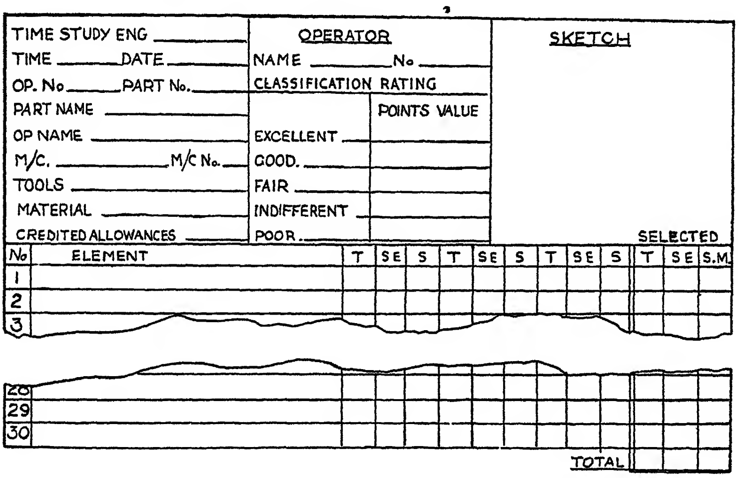


FIG. 12
This shows the heading of Fig 14 in detail

The best position to use the watch and board is to be (where possible) in front of the operator so that all the motions can be observed. The watch should be held at the top of the board, usually at the left-hand corner, and the line of sight such that the eye can travel from the field of operations to the watch and then to the board with the minimum of movement. (See Fig. 4.)

While the observer is watching the operation, he will be estimating the speed of the operator; then, as the cycle for that particular element ceases, he will switch his concentration to the study sheet pinned on the board, via the watch, record the reading in his mind, flash the watch back to zero, so that it starts off again immediately, and then transfer both the time and the speed and

effort rating to the study sheet. It is important that speed assessment is recorded independently of the time factor; it will be done at the same time, but the observer must avoid altering the speed rating to suit the time. This is easy to do, and if the study has a perfect look it is suspicious!

Immediately he has finished recording the element's time and rating, his eye must travel back to the job in order to pick up the next element.

This function of recording has to be done with the utmost dispatch; otherwise, if time is lost in recording, then the rating efficiency of the immediately next element will suffer.

In some organizations it is customary for the observers to rate only every other element, merely recording the time for each element, and as the next complete cycle starts, so the rating will automatically be applied to those previously missed, while those elements previously rated will carry only times on the second cycle.

It all depends on the type of study If the time cycles are very small, then it is more efficient to use this method of alternative timing.

There is still another alternative to cope with those elements which are particularly short cycled, and that is to batch them. By this is meant that it would be preferable to time, not one at a time, but every three or four, depending upon the time factor involved.

The efficiency of the "flash-back" type of recording may be questioned by the critical student, who will observe that if the watch is being "flashed back" to zero each time, then clearly some time must be lost. This is so, in the normal run. However, this time lag is so small that it does not throw up. Some observers overcome the difficulty by reading forward, e.g. if the reading was $16\frac{4}{5}$ seconds, 17 would be recorded.

This is where the continuous reading method scores. This is done by means of the decimal minute watch. The watch is started when the operation commences, and as each element is completed so the time is recorded. Thus the elemental timing is recorded by subtracting the times from each successive reading. This method has the advantage that it entirely eliminates the "flash-back" time lag, and, in addition, evidence seems to point to the fact that it is less fatiguing to the observer.

One disadvantage is that the clerical labour is increased by the fact that the subtraction has to be done for each element and for each reading. There is so little to choose between the two methods

that there is small gain in discussing the comparative methods further. The simple write-ups shown below and on page 56 will demonstrate the methods of both timing and rating.

TIME STUDY SHEET

SHOP NO.......... ...... DEPARTMENT... ... . T S ENGINEER....... ....
MACHINE NO........... M/C NAME .. .... M/C FEED.... SPEED..... ....
OPERATOR'S NO...... ... MALE FEMALE . . .. . BEGAN . . FINISHED. . .OAT . ...
OPERATOR'S NAME. ... .' ALL IN" RATE.. FATIGUE GROUP...... ....
PART NAME...... .... CODE NO . ...MODEL NO...........

NO	ELEMENTS	T	SE	L	T	SE	L	T	SE	L	T	SE	L	T	SE	SELECTED T	SE	S.T.
1	Up from left & place in Collet & lock	8	70		9	70		6	95		7	80						
2	Start M/C & bring up facing tool	30	72		27	78		27	78		36							
3	Point	6	70		5	75		5	75		5	75						
4	Turn	24	75		24	75		21	80		21	80						
5	Stop M/C (Slow with hand)	5	72		4	75		5	72		5	72						
6	Unlock collet & aside pin to tin on right	6	75		6	75		17		-	6	75						

FIG. 13 SAMPLE STUDY "A"

FOREIGN ELEMENTS

In the examples it will be seen that certain items are ringed out, and that there is no rating noted against them This is because during those particular observations the operator introduced a "foreign" element. This might have been using a handkerchief,

taking an unnecessarily long time over an ancillary operation, dropping a part, fumbling and, in short, taking up such time on a motion that is unjustifiable; to include the time would be to admit an allowance that was not called for. Apropos of this, although it might be argued that to use a handkerchief is justifiable, it must be remembered that an allowance is to be added for personal

TIME STUDY ENG J. Dawes TIME 4/30 DATE 26/8/42 OP No 321 PART No 4219 PART NAME Pin OP NAME Face, Point & Turn M/C Turret M/C No 46	OPERATOR NAME F. Bird No 329 CLASSIFICATION RATING EXCELLENT GOOD ✓ POINTS VALUE Not Required	SKETCH

NO	ELEMENT	T	SE	S	T	SE	S	T	SE	S	T	SE	S
1	Up from left & place in collet	13	70	13	13	70	15	10	95	10	12	80	12
2	& lock												
3													
4	Start m/c & bring up facing tool	63	72	50	60	78	45	55	78	45	72	—	—
5													
6	Point	73	70	1	68	75	08	63	75	08	80	75	08
7													
8													
9	Turn	113	75	40	108	75	40	98	80	35	115	80	35
10													
11													
12	Stop m/c (Slow with hand)	121	72	08	114	75	06	106	72	08	123	72	08
13													
14													
15	Unlock collet & aside pin	131	75	10	124	75	10	134			133	75	10
16	to tin on right												
17													
18													

FIG. 14. SAMPLE STUDY "B"

Opportunity has been taken not only to indicate the difference in the timing (this specimen is in decimal minutes), but also to offer an alternative suggestion for the Time Study Sheet. In this it will be seen that provision has been made for a sketch and also that an extra rating has been introduced, viz. a classification rating. This is to safeguard the observer on future occasions against claims that the operator standard has been raised or lowered. In this sample the continuous method of reading has been adopted and under "S" is the subtracted time

needs. So in much the same way that one would not admit time for using the cloakroom in the actual timing, so one cannot permit time factors such as talking, or other personal needs.

This raises a point in connexion with some operations where cleanliness is necessary. For instance, if the job includes a varnishing operation, it is obviously better to time the actual wiping of the hands, in order more easily to handle a part, than to make an overall

allowance. The actual wiping is rated under these circumstances, which makes it a much fairer allowance. (Similarly, with cleaning the solder tip of an iron, or the removal of swarf from a machine.) This factor is important, too, from the point of view that subsequently it is just possible that a claim for an extra allowance may be made to cover these very operations, with the result that, if it is included in the study as an element, there can be no question of a dispute, whereas it is very probable that, if the time is allowed as an extra allowance, there will be some doubt as to exactly how much of the allowance is governed by these extra elements.

Certainly, in the case of talking to other operators, and the using of handkerchiefs, no claim will either be made or can be entertained.

In the above studies no account has been taken of such interruptions as occur during the normal day's work. This is because the basis of any time study standard must be the compilation of data and information If the purpose of the study is merely to set a time value and rate, then the study need not be so meticulous. But if time study is to be used to the full, the building up of standard values for a " synthetic " library is the prime reason for such care and attention.

During the course of the study, interruptions will occur which have to be ignored in order that a full efficiency rating shall result However, during the course of a day's work in a normal factory, minor inefficiencies occur, such as delays due to shortage of material, changing of machines, tool attention, interruptions due to change-over of material, and temporary hold-ups due to inspection wanting to take a line check, and so on. Some of these cases (tool attention, to quote one) can be covered by the issue of a waiting card, but if the attention is so little that it is not worth while issuing waiting cards, then obviously some sort of allowance must be given to cover local conditions.

These are minor inefficiencies, the sum of which can add up to quite a large proportion of the bonus inefficiency, thus penalizing the operator. Standard practice must be the guide in such cases, but on the whole 2½ to 4 per cent seems to be a fair average, dependent upon the degree of efficiency experienced by the firm concerned. The reader should be warned against giving a generous allowance for these contingencies; there is a tendency then to exercise the allowance to the full, resulting either in the inefficiencies growing and thus upsetting the standard or the allowances being used as an excuse to get an easement on the rate, both cases resulting in an unhealthy state of affairs.

LENGTH OF TIMING CYCLES

In the examples shown so far, the number of readings has been limited; this is in order not to confuse the issue. It should be appreciated, however, that it is practically impossible to get accurate ratings on a few cycles. The actual number of readings necessary to cover the job depends entirely on that job. In the majority of cases, not less than 15 should be an aim, and anything up to 40 in cases where it is felt that sufficient coverage must be made in order to find all the variants. Certainly, the longer the study, the greater the accuracy In some organizations it is felt that the sooner the job is rated, the better it will be for all concerned; the firm benefits by the fact that the cost of studying is reduced, and the operator because the rate will be "on the floor" more quickly. A moment's reflection will show how much of a fallacy this is. In fact, the less time the observer spends on the job the greater the inaccuracy. Certainly in most cases the rapid study reacts unfavourably on the operator. Most observers tend to rate low, in order to shield themselves from the charge of giving loose rates. It is only by constant application that this perfectly natural tendency is overcome by an appreciation of the operator's difficulties If a "tight" rate goes to the floor, the natural reaction of the floor supervision is to demand a re-study, whether justified or not; this must be given, and the net result is loss of time to the time study department. Apart from this consideration, however, there is another important point. Nobody likes to think that he, as an individual, is worthy of scant attention, and the short, sharp, snap study implies that the job is not worth studying anyway, with the unhappy result that the operator feels that insufficient care has been taken, and even if the rate is a fair one, is more likely to prove obstructive next time. No, the more care that is given to the study, the greater the accuracy.

EXPRESSING THE RATE

Having decided what the rate is to be, how is the rate to be expressed? There are several popular methods. Here are a few—

Pieces per Hour (Flat). This gives the number of pieces the operator must produce in each hour to break even. It is the target that has to be exceeded, and thus is expressed in terms of either "base rate" or "flat rate," since it is the minimum number required before any sort of bonus can be paid. It is a very good scheme, and has the advantage of allowing the wages department to work out the percentage of bonus without much trouble. This is

an important point to remember, since the wages department is part of the factory "burden."

Bonus Pieces per Hour. This is a better way of presenting the target. It is based on the expected bonus, i.e. if the normal expectation is 25 per cent bonus, then the pieces per hour thus expressed will be at this figure. This leaves no doubt in the operator's mind as to how many must be produced to earn bonus. If operators beat the figure, then of course they are given the extra bonus, and if this is clearly expressed there can never be any recrimination that the bonus figure was ambiguous. One disadvantage is that the wages department have to convert the number of pieces in order to compute the bonus to be paid.

Hours per Hundred (Flat). This is the expression in time value. It shows the number of hours or part of an hour allowed per hundred pieces. It is a convenient way of expressing the rate for the wages department, but very difficult for the ordinary operator to convert back the pieces per hour. Thus it is not a practice to be recommended, unless the pieces per hour is also quoted.

Hours per Hundred (Bonus Time). This is a case similar to the former, except that the calculation is carried a stage further by reconciling the rate to the bonus speed expected.

Job Hours Allowed. This is by far the better method of expressing the rate. Time study, either from the study or from records, reconciles the time to suit the actual schedule; thus the operator is made immediately aware exactly how long is allowed to complete the task. This expresses the rate in a manner satisfactory to all; the operator can calculate the time saved easily; the charge-hand can estimate when the machine will be free; and wages department can see from the clock or job card exactly how much bonus is to be paid. But its main advantage lies in the fact that there is little risk of the operator gaining a false impression of the bonus, which very often happens with other methods. This "target setting" imposes more work on the time study department, but as this job is actually more likely to be done by clerks, it follows that this one disadvantage is outweighed by all the benefits.

Another important point to consider is the imparting of the information as to the bonus earned by either the group or the operator. In any case, the operator will want to know how much he, as an individual, has earned during the week.

Probably as important is the demonstrating to the operators how their bonus is computed.

Here are two examples. "A" is the scheme worked out on the

premium bonus system, and "B" is the calculation for the standard times scheme. It is suggested that the information that it is desired to impart is included in a small booklet that will also carry details of the "Conditions of Employment" and other relevant matter.

"A" PREMIUM BONUS SCHEME

The following factors are required to work out the bonus—

Time Allowed, expressed as "T.A."
Time Taken, expressed as "T.T."
Time Saved, expressed as "T.S."

All the jobs performed by the operator during the week (or day if daily records are kept) are totalled, thus giving the Total Allowed Hours. The time spent by the operator actually producing, i.e. after deducting waiting time, day work, etc., from the weekly (or daily) hours, is added, thus giving the Total Time Taken. T.T. is subtracted from T.A. and the product is expressed as a percentage of T.A. Thus the answer is found for the determination of the reward and the percentage is paid on the basis of the Total Time Taken.

"B" STANDARD TIMES SCHEME

The same factors are involved, i.e. Time Allowed (T.A.).
Time Taken (T.T.).
Time Saved (T.S.).

In this example, however, the calculation is simplified for the operator because he does not have to work out the percentage; he gets the T.S. in his base rate hours.

An example of the type of notification that can be used both as a guide to the wages clerk and to the operator is shown in Fig. 15. This is in sheet form and the calculations are recorded by means of a carbon copy.

W/E	Name	Total Hrs	Waiting	All'd Hrs.
		Total Hrs.	Waiting	All'd Hrs

FIG

This specimen payment notification is duplicated and typed off from an analysis, one packet. This gives the operator a true picture of how his money is made up Perforations be torn

PERSONNEL RELATIONSHIP

There is one aspect of management that is involved every time that the observer goes into a shop to study a job, and that is the reaction of the operator. The human touch is so patently necessary that it seems unnecessary for the point to be mentioned at all. However, so much trouble has been caused by the casual attitude of the time study observer, that it must be emphasized. Operators, in the main, are not dishonest. The attitude adopted by some observers that operators are always out to get the best rate may be true in a large number of cases, but not in the majority. Where it *is* true, it is usually the result of maltreatment over rates in the past. Normally, the average operator is quite willing to co-operate and put his best into the job under study; where this is abused by an exceptionally tight rate, or by the observer rating the operator low, trouble can only ensue. The time study department will do much to win confidence, and so reduce arguments and friction, if it gives fair rates. This is not to say that it is needful to make rates loose in order to win acceptance, but it is necessary that the rate is not only fair but is rechecked immediately there is a query, even if the query is considered to be frivolous. The reason for this is that once it has been established that the time study department set fair rates, and are prepared to substantiate them, the prestige thus accumulated will do much to build up trust between the operators, supervision, and the time study department

THE FOREMAN'S ATTITUDE

Where antagonism is met from the supervision, this, it should be remembered, is based to a certain degree upon the fact that supervision's efficiency is often measured upon lack of operator discord, and they cannot be blamed for assuming that the rating

Hrs Taken	Hrs. Saved	%	Bonus Hrs	Rate	Amount
Hrs. Taken	Hrs Saved	%	Bonus Hrs	Rate	Amount

15

copy remaining in the wages office, and the other being slipped into the operator's pay are to permit the whole bunch of slips being typed in one machine and enabling each slip to off as required.

which inclines too tight upsets the operators. This presupposes friction, and thus rebounds upon the time study department. Very often supervision will instinctively support the operator's complaint without investigating it, solely due to the fact that they wish to give the impression that they are "on the side of the operator." This is an attitude to be deprecated, but it is understandable. It should be recognized as a regular condition and steps taken to overcome it. The thing to avoid, if possible, is any sort of dogmatism about rates. Even if the observer is assured of his correct rating, it must be expected that both the supervision and the operator are themselves not certain, and steps must be taken to remove any doubt.

"Proving" a rate is very helpful. This is accomplished by means of the "seconds" stop watch. It is laid on the bench in full view of the operator and started when the operation is commenced. According to the number of cycles it is stopped when the operation is finished. This permits the operator to read the time taken, and if the rating is correct, and the operator has not been deliberately going slow, the answer should show some time saved, and therefore bonus earned, compared with the rate as set.

In the event of the operator deliberately going slow, this should be apparent to the supervision. It is then up to the supervision to take the necessary steps. In most cases this deliberate "go slow" policy can be detected easily enough, even by the unskilled observer, and in any case recourse to another operator will be sufficient to provide a comparative speed It is rare that two operators will be found who work at exactly the same speed.

Co-operation is the ideal. If this can be attained, then there is no doubt that the work of the time study department will be immeasurably lightened. How can this be obtained? There are several proven methods.

COMBATING RATES-RESISTANCE

One of the most common is to hold management meetings at which various problems are discussed and remedies suggested. At these meetings it is customary for the various heads of the departments, or their deputies, to describe the work that the department does. This is then applied to the meeting with a view to obtaining suggestions. The development of the debate technique is very valuable, because not only does it provide a means of self-expression, but at the same time it helps the participants to develop an open mind.

A ready appreciation of "the other fellow's point of view" is one way of overcoming mental antagonism. It is no use assuming

that the other man cannot be of assistance merely because he happens to be ignorant of the intricacies of the job. This is a proven misconception. Nobody can know so much about one branch of his work that he can afford to ignore outside assistance. Once this point is established, the co-operation that is so necessary for the smooth running of an organization and the development of team work will be forthcoming.

Another method of obtaining co-operation is to take the supervision into the time study department's confidence in the matter of rating. Some organizations debar this on the grounds that the shop supervision will soon be setting their own rates! What is doubtless the prime worry is the fact that the supervision will probably be trying to check the rates. And why should this not be so? The implied answer to this is that the time study personnel by their greater experience must always be right. This is not necessarily so, but it is conceded that the untrained observer will get a different answer. However, this is beside the point. The greatest reason for describing the rating system is to demonstrate to the supervision the fact that the rates are calculated and not just based on some vague idea that the stop watch gives the answer—the answer which supervision think is always the lowest time recorded!

Perhaps one of the best methods of gaining co-operation is for the management to issue "terms of reference" This means that all the supervision will be made aware that the main duty of the time study department is to be the provider of standards of measurement, and that the department which does not use this "yardstick" of labour cannot be considered efficient.

CHAPTER VI

ALLOWANCES AND COSTS

LEARNERS are usually treated differently from the skilled operators. It is obviously impossible to expect learners to work at the same speed as the more skilled operators; if no adjustment were made it would mean that the learners would be penalized. Worse still, in the sense of groups working together, the learner becomes a "passenger" to the detriment of the group as a whole, with the result that the skilled operators are losing bonus—a state of affairs hardly calculated to encourage operators to work hard.

In the case of the individual operator who is a learner, it is customary to notify the wages department that for a certain specified period (dependent on how long it takes to learn the job) the operator will be paid a lieu bonus, thus guaranteeing that minimum yet allowing the operator to make the maximum if the learning period is voluntarily shortened by the special aptitude of the new operator. In the case of group bonus, the wages department is usually advised that the group will require an extra allowance to compensate for the learner, which will also be subjected to a specified time limit

ADJUSTMENT SCALE ALLOWANCES

It will be seen that a chart (Fig. 16) based on this principle permits the operator to receive the maximum benefit for a pre-determined period. The chart shows a trial period of six weeks, but this can be adjusted according to the needs of the job being learnt.

Under "earned performance" is the rating value as shown by the production of the operators against time taken. According to what has been produced, so a compensating rating is applied in order that the operators shall receive some bonus, although, in earlier stages, none at all has been made.

The introduction of an incentive scheme into shops or departments where such a scheme has not been in operation before invariably results in a falling off of the expected yield, due to one or more of the following causes—

(*a*) Time study rates set too high a standard for existing operator-efficiency.

(*b*) Shop conditions do not permit operator development to time study conception of efficiency.

(c) Habit plays an important part. Because there has been no previous measurement of efficiency, the shop or shops have become overloaded with personnel, and since time study standards call for increased speed of working, the operators and shop supervision find it difficult to reconcile the number of operators asked for by the time study department with the number of operators they themselves have preconceived.

ADJUSTMENT SCALE

AVERAGE WEEKLY OPERATOR HOURS=4975

WEEK COMMENCING	NO OF OPERATORS	T. S. ALLOWED HOURS	ACTUAL WORKING HRS (INCLUDING OVERTIME)	EXTRA ALLOWED HOURS REQUIRED TO MAKE BONUS (IN COL 7)	TOTAL ALLOWED HOURS (INCL COL 3) REQUIRED TO MAKE BONUS IN COL 7	% BONUS	% ADDITIONAL ALLOWED HOURS % OF COL 3
1	2	3	4	5	6	7	8
MAY 17	16	820	812 0	340·0	1160·0	30	38
" 24	15	820	762 25	270·0	1090 0	30	33⅓
" 31	14	820	712·5	275·0	1095·0	35	33⅓
JUNE 7	13	820	662·75	200 0	1020 0	35	25
14	12	820	613 0	200·0	1020·0	40	25
21	11	820	563 25	120·0	940 0	40	15
28	10	820	513·5	112·0	932·0	45	10
JULY 5	9	820	463·75		820·0	43 6	

FIG 16

The above Adjustment Scale is based on Premium Bonus and not Standard Times. This is because it is extremely unlikely that any organization using such an Adjustment Scale to introduce a bonus scheme will be using Standard Times It can, however, be easily adapted to Standard Times if required

To overcome these difficulties, therefore, and to offer an inducement to the operators to make bonus, and also to stimulate interest in the incentive scheme, an "easement" scale of allowances is devised. (See Fig. 16.) Strictly speaking, this is not a "learner's scale," since this would imply that the operators themselves are learners, whereas in actual fact they are experienced operators working under a different set of conditions.

The adjustment scale calls for a reduction of operators to time study standards spread over a given number of weeks. By this means it also calls for an increase in output per operator spread over the same number of weeks.

The scale is set on the Rowan scheme, on the theory that any *new* incentive is almost certain to be a premium bonus scheme.

As an immediate reward, time study standards are re-valued, in order that the operators working to the adjustment scale shall earn some bonus immediately. The bonus, however, is not limited in any way except in regard to its minimum value. In other words, where an actual percentage of hours is mentioned, that, in effect, represents the minimum bonus, but generally there is no maximum limit.

The guaranteed minimum progresses in fortnightly periods from 35 by 5 per cent until the optimum is reached. The optimum in each case is the normal standard hours allowed for by time study upon which bonus can be made. Be it noted that the actual amount of bonus that *can* be made is not quoted. This is done from a wish to avoid confusing the issue.

The scale is divided into eight columns, numbered consecutively from 1 to 8, and headed as follows—

1. Week commencing.
2. Number of operators.
3. Time study allowed hours.
4. Actual working hours, plus overtime of x hours, less any day-work hours.
5. Extra allowed hours required to make bonus (Column 7).
6. Total allowed hours (including Column 5) required to make bonus (in Column 7).
7. Percentage bonus.
8. Percentage additional allowed hours expressed as a percentage of Column 3.

Under *Column* 1 is set down the week commencing date. This always refers to the particular week in which the scale is going to operate. Contrary to usual custom, the week ending date is not used. This is to ensure that the target is always predetermined.

Under *Column* 2 is set down the number of operators in the group that are to be allowed to earn bonus, providing that the schedule or target is met during that week.

Under *Column* 3 is shown the time study allowed hours, and this figure is constant throughout the whole period of the learner's scale allowances. Incidentally, the time study allowed hours include a factor of x per cent, which is a figure agreed upon to compensate for shop conditions, fatigue ratios, etc.

Column 4 is made up of the actual working hours spent by the number of operators shown in Column 2, multiplied by 49·75, being one week, including Saturday morning, plus the normal number

of hours overtime worked by these operators, and less any time for day-work, etc.

Column 5 shows the extra allowed hours. This is the figure which, added to Column 3, will permit the number of operators shown in Column 2 spending the amount of time shown in Column 4 to make bonus, providing they make schedule.

Column 6 is the sum of Column 3 and Column 4.

Column 7 shows the minimum bonus that will be made providing the foregoing conditions have been met.

Column 8 indicates the extra allowance in Column 5 expressed as a percentage of allowed hours that must be added to Column 3 in order that the previously mentioned bonus may be made.

The formula for this is as follows—

The actual working time has been taken and, if the operators are required to make 35 per cent, the actual working time is set down as 65/100ths, and by finding the value of $\frac{100}{1}$ is discovered what total of hours will be required to make 35 per cent bonus. From this figure is deducted the time study allowed hours, which gives the difference in allowed hours from the total allowed hours required to make bonus. This figure having been found, it is then expressed as a percentage of time study allowed hours, so that providing the same proportions are maintained throughout the working week, e.g. if 75 per cent of the hours are taken and only 75 per cent of schedule is made, then the additional percentage required will be maintained, and therefore the scale can be safely applied.

Theoretically, the scale is applicable as it stands. In actual practice, however, it is generally agreed by management that, providing the bonus made is reasonable, it will be paid, i.e. if above the minimum figure quoted. If, however, the figure is fantastic, for instance if 35 per cent bonus is called for and actually 75 per cent is made in the first week, it would be obvious that this is due to a wrong assessment of labour requirements, which is beyond the control of the time study department, and a compromise would probably be made to pay the group 50 per cent.

It is usually stipulated by management that at the end of a certain period the time study department will investigate any groups found to be making either (*a*) exorbitant bonus, or (*b*) low, or no bonus at all. If the bonus is inordinately high, then the scale will need to be adjusted to meet this contingency. If the bonus is low, then again the scale will have to be adjusted, but this time with new standards supplied by the time study department, because if, after

running for a reasonable period, the bonus being made is still low, there is some justification for the assumption that the rates are tight, or that insufficient allowances have been made for local or domestic conditions, and steps can be taken to increase the allowed hours on a permanent or temporary basis as required.

RECORDS MUST BE KEPT

It is important that the time study observer working in the shop should record the changes that occur from the date of the application of the scale. For instance, as the number of operators per group is reduced, so the working space or area will be increased, and this in turn should permit greater freedom of action with a consequent rise in efficiency. Therefore, shop conditions would not necessarily demand the addition of a compensatory percentage, and this figure could well be reduced according to current practice.

It should be agreed that where operators are moved from groups under this scale, those operators should not be assigned to other groups in the same shop unless they can be considered skilled, so that their lack of previous experience will not prove a bar to the making of bonus by the freshly assigned group.

It should also be agreed by management that the number of operators on each group should not be increased except in exceptional circumstances. This is important because the increasing of the personnel without a corresponding increase in production will jeopardize the bonus being made, for the simple reason that to increase the number of operators is to increase temporarily the time taken by the group, and unless the incoming operator is sufficiently skilled or intelligent to be able to work at the same speed as the rest of the group, obviously this operator will be considered a "passenger" for some time; it is necessary to avoid this in order to obviate the need for increasing the percentage to the allowed hours to compensate for raw personnel.

This is true, too, in the case of absentees. It is undesirable when absenteeism has occurred to reinforce from a group already running, because it will take some time for the natural dexterity and smoothness of working to be restored.

Therefore it would be as well to consider the question of maintaining a reserve of labour in preference to increasing labour at any given moment. The reserve labour for the time being could well be incorporated into the "Indirect Bonus" scheme, because it will be considered as consisting of "first-aid" operators, able to step in at any given moment and pick up any job. An alternative is

to pay these operators the higher base rate and to increase their status in the shop.

PAYING FOR RESULTS

The institution of any incentive scheme brings to the fore the old controversy of how the bonus shall be paid. Shall the rate be applied to a group or to the individual? Both schemes have much to commend them. Here, then, is an analysis of the merits and demerits.

Groups. Where there is a large number of operators, "burden" is reduced to a considerable extent by the employment of the group system. Less checkers are required and less work devolves upon the accounting system.

To achieve the group system all the operators are rated individually, so that the supervision can apprise each operator of the rate necessary to produce bonus. But the operator does not book against the individual rate, but against the group, so that the total hours taken by the group to produce x parts can be calculated. The individual rates for the operations are then totalled and converted to hours per hundred complete assemblies (or produced parts) so that the bonus rate is applied to the group as a whole.

This then is the application of the rate. Its advantages lie in the fact that checking is made a comparatively easy matter; there is no question of the parts becoming mixed and the wrong operator being credited with the parts, wages department can easily compute the bonus earned without having to analyse the individual clock or job cards.

Its disadvantages are: because the rate is fixed to the group output, it is easy for "passengers" to be carried; the individual incentive is lacking because the natural tendency of any operator is to work hard for one's self and less so for the common weal. If any one operator fails to carry an equitable load, then the bonus earnings for the whole group suffer, with the result that the group rapidly becomes disgruntled.

One must, in all fairness, add that there are some groups which have an *esprit de corps*, but one must also admit that where there is uncertain and mixed labour, this is not a factor upon which one can rely. Faulty work is more difficult to assess, and again the whole group can be so easily penalized for the bad work of one undetectable operator.

The onus of deciding upon the working capacity of each operator falls upon supervision, and under the stress of present-day competition this might be asking a lot from the supervisory staff.

There is also a very natural tendency to increase the operator-per-hours-part in order to make schedule, with the result that again the group will suffer. Learners and their depleted earnings can affect the group bonus despite all that is done to guard against it, even to the extent of booking off the group.

Individual Rates. One of the difficulties here is that close checking is required and the need to augment the checking staff increases the oncost. The larger the shop, the greater the need for efficient checking. There is, too, a greater burden upon the wages staff. Every clock card has to be scrutinized and each allotted a separate bonus payment; now this obviously means a great deal more work for the non-producing elements of a factory, and that is the reason why so many works managers favour the group system! Clearly, in these days of high-speed production and the need for a low ratio, the less "indirect" workers the better.

The advantage of the individual rates lies in the greater, much greater, incentive. Where the operator is actually paid for the work produced, then the production cannot but be enhanced. On the individual scheme there can be no question of "passenger carry"; any falling off either in enthusiasm or energy is reflected in the weekly pay packet, and that hits the operator where it hurts most—in the pocket. One of the main objections against the employment of individual rates is that it lends itself to abuse which is sometimes difficult to detect. Certainly, abuse of this kind is a serious matter, involving as it does the direct implication of fraud, and this surely is a matter of discipline.

Pro rata, the individual rates are worthy of the extra overhead burden, since the net result is increased production, and that is important. If we accept the fact that efficient maximum production is the prime object of a factory, any incentive scheme must necessarily be applied to the individual in order that it shall be a *real* incentive, and that every operator shall pull his or her weight to the uttermost.

Another advantage of the individual rate, and it is a very real advantage, is that idle time is easily computed; with the group system it is very often hidden or swallowed up in the general allowance to the group, with the result that the costs department does not get a true picture. Machine loading loses its point if the idle time is not revealed, and total capacity can never be really attained. With the individual rate, however, operators no sooner complete the task than they are after another job in order to maintain a high ratio of bonus. This is reflected in machine capacity,

since it is impossible for the operator to lose machine hours *undetected*.

ORGANIZING THE PAYMENT

Whatever the system adopted, whether premium bonus, standard times, group or individual, the same principles hold good as regards paper work for paying and methods of calculation Here is a brief analysis of the wages methods required.

The basis of all incentive is time The number of hours worked by an operator governs the amount of money that operator will receive. Since most operators are hourly paid, the base rate per hour is the controlling factor To exercise this control some system of booking in and out during the day and week is required. This is usually covered by a clock card. The clock card can be used as a bonus record (which is the more desirable since it "bulks" the information for wages computation). In Fig 17 will be seen a specimen card for daily records.

In most organizations the flow of parts through the factory is controlled by part numbers, the operation is also numbered. Taking the example shown, the operator coming at 8 o'clock would book on the first "on" space The charge-hand or inspector would fill in the part number and the operation number. As the operator books off at lunch time, so the inspector would fill in the card with the number passed. This system is followed throughout the day, booking on and off jobs as they become finished. If the operator works throughout the week on one job, then the part and operation number follows through automatically. The card is a daily card, and thus each day following the day's work the parts are totalled and the bonus worked out from the rates supplied by the time study department. A Kardex system is recommended for this filing reference. As it will sometimes happen that an operator will be working on several jobs during the day, it is likely that one card will become exhausted, in which case, to avoid losing track of the day's output, the continuation card is clipped at the space indicated in the top right-hand corner.

This method is the one suggested for individual operations, but where a group is involved, the part and operation number need not be quoted; in place of these the group number is used. Time study will have supplied the wages department with the allowed hours per hundred parts for the group, as in the case of the individual operator.

This is a simple way to overcome the delay associated with the

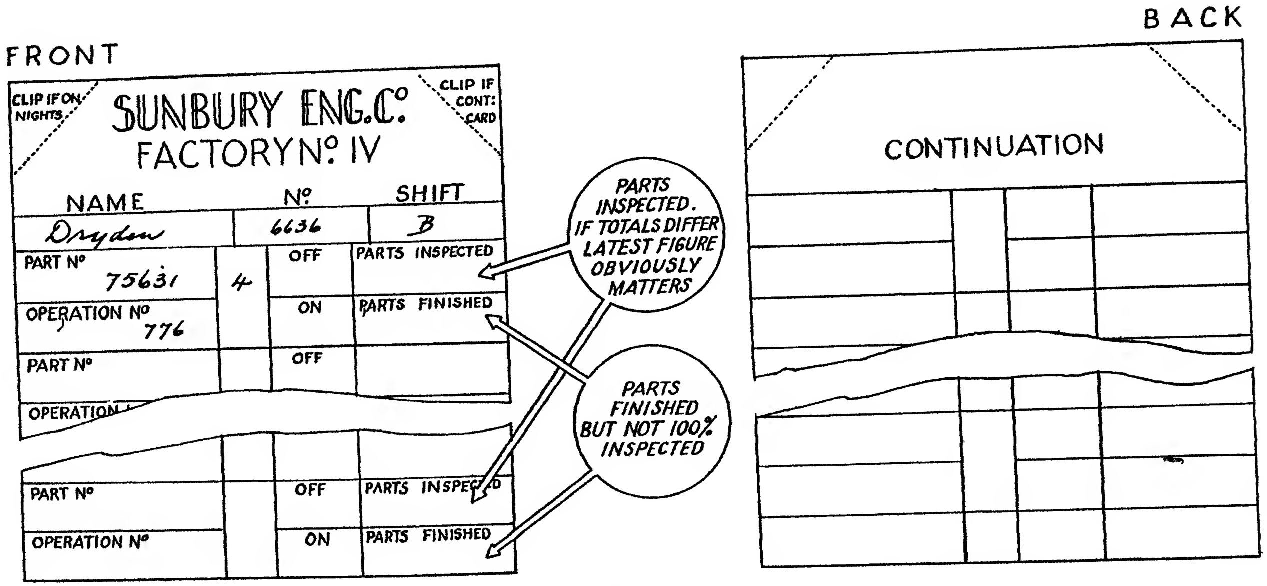


FIG 17

The above Clock Card is designed to take care of individual operators working on an incentive scheme If, however, operators are members of a group, the group number only would be recorded in the sections reserved for the part number and operation number.

weekly analysis of output returned via inspection or checking departments.

PROGRESS RECORDS ALSO CONTROL PAYMENT

An alternative method is to issue progress charts to the inspection, and the number of parts to be paid for. The operators then produce against the progress chart and the parts are then credited against the operator's name. In the case of a group, a similar system is followed except that the group number is quoted instead of the name of the operator. At the end of the week the total number of parts produced is computed; this multiplied by the time allowed gives the total allowed hours. From this figure is subtracted the number of hours taken according to the group or operator, and the bonus calculated from this.

This means that operator transfer from group to group has to be advised to wages; waiting time has to be recorded separately (on the card system this is recorded in the part number section), all of which adds its quota of clerical work.

LABOUR COSTS

To be effective, time study must effect savings in costs. This must be recorded in an easily understandable manner in order that the full value can be reaped from the department, and an efficient cost control system initiated.

The analysis (which should be extracted weekly) should give—

(1) Percentage of operator-efficiency, which is summed up as follows: Average bonus paid. Average bonus earned, the difference of which is governed by learner, adjustments, extra allowances, guaranteed bonus, etc.

(2) Percentage of day-work to bonus hours produced.
(3) Percentage of waiting time and whose debit charge it is.
(4) Ratio of indirect costs to direct costs.
(5) Ratio of direct hours to indirect hours
(6) Analysis of indirect labour, i.e. clerical, supervision, etc.
(7) Production costs per schedule or per 1000 hours.
(8) Waiting time, distribution of costs, and responsibility.

An example of a costing sheet will be seen in Figs. 18 and 19. It will be noted that the value is expressed in "A" hours, i.e. Allowed Hours. Of course, any formula can be used, providing that it expresses a time value, because the measurement of time, shown in pence or allowed minutes, must be the basis of any system of labour costing.

DEPARTMENT

SUPERVISOR.

WEEKLY ANALYSIS SHEET.

WEEK ENDING	NUMBER OF OPERATORS		HOURS			DIRECT LABOUR A HOURS						LABOUR UTILISATION				
	ON DIRECT LABOUR	ON INDIRECT LABOUR	ON DIRECT LABOUR	ON INDIRECT LABOUR	TOTAL	A's OF DIRECT LABOUR	N. O. B AT 60 A's/HR	RE-OP	GROSS TOTAL A's		NETT TOTAL As	OPERATOR	A-HOURS DIRECT	QUALITY EFFECTIVENESS		
REF. PERIOD																
QUARTERLY TOTALS																

FIG 18

This Weekly Analysis Sheet will give a direct control over both the direct and indirect labour costs In the first column the week-ending date is recorded, in the second the number of operators is extracted from the clock cards or progress sheets In the third column the hours are extracted from the same source. The fourth section shows the total allowed hours spent by direct labour and the amount of day work which is debited at "60," i e. flat or normal The amount of time spent on the operation is also calculated at the same rate. The sum of these gives the gross total of allowed hours, a net total is arrived at by subtracting any non-operational factors that can be listed in the vacant column. The labour utilization section is self-explanatory

PROTECTION OF EARNINGS	OVERTIME ALLOWANCE		SUMMARY OF COST PER 1,000 DIRECT As											ADJUSTMENT FOR SUPERVISION EFFECTIVENESS	EFFECTIVENESS A-HR INDEX	
			DIRECT			INDIRECT			TOTAL						SUPERVISION	DEPARTMENT
			ACTUAL	STANDARD	%	ACTUAL	STANDARD	%	ACTUAL	STANDARD	%					
£. s. d.	£ s. d	£. s. d	sd	d	EXCESS	s.d.	d	EXCESS	d	d	EXCESS					

FIG 19

Where any learning scales or *ex-gratia* payments are being made, these are considered "protection," and therefore have to figure in the cost of the product and, because they are directly concerned with the cost of the product, they do not figure as an overhead Overtime is also reckoned on the same basis, so therefore this alternative analysis sheet is offered as a suggestion

TIME STUDY AND MACHINE LOADING

Another important part of the function of the time study department is to co-operate in the control of the machine-efficiency. For this purpose, and it is an integral part of the time study responsibility, the liaison with the production (machine shop) department should be as intimate as possible.

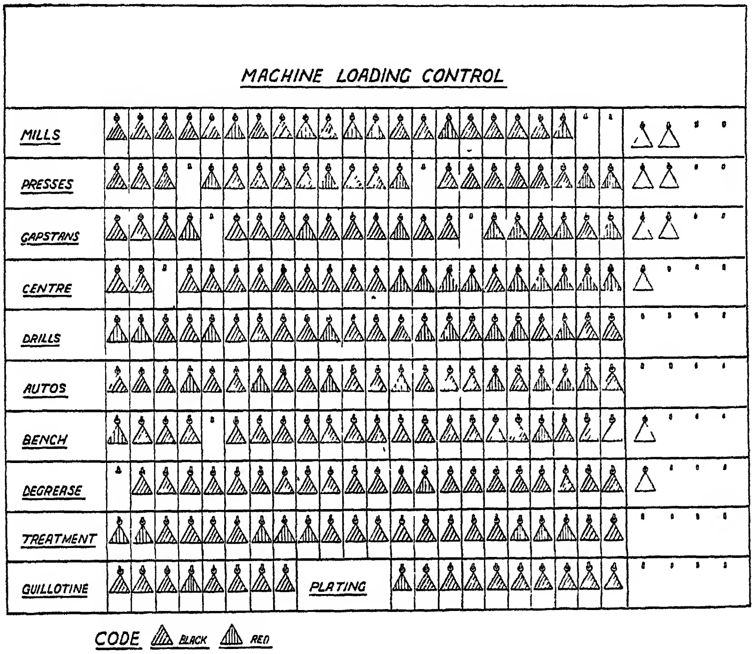


FIG 20

This simple machine loading control board will enable the Time Study Department to achieve maximum study efficiency by being saved fruitless journeys when the machines are out of action Needless to say, close liaison must be maintained between Production Control and Time Study in order that the board will remain up to date

The machine shop production control will have its own Machine Loading Chart, but in order that the time study department shall be in a position to evaluate the efficiency, some sort of machine loading control should be kept by the department. An example is given in Fig. 20. This specimen does not give the details of the parts that are loaded on the machines. This is not necessary since the time study department is concerned only with the reasons for

lack of loading. For our purpose they are divided into two· (1) waiting; (2) breakdown.

If the machine is not running and rates are required from it, then it will be easy to avoid wasted journeys; on the other hand, if a machine is waiting on service because of breakdown, then it is obvious that time setting cannot take place. Contact is usually maintained by house telephone.

CHAPTER VII

THE APPLICATION OF TIME STUDY TO DIFFERENT TYPES OF WORK

CAN time study be used in other branches of industry? It has already been explained that other industries use time study and the answer is now obvious. Time study has been successfully applied to all forms of labour in both direct production and indirect. Inspection has been time studied, so too has trucking and transport. All forms of industry render themselves open to time studies, and it is safe to say that there is not a single section of industry, whatever the complications, that cannot be time studied and improved.

It follows that the more the mental effort required, or even special skill, the more difficult will be the study, but two more diverse sections of industry than toolmaking and typing could not be imagined, yet these two have been successfully studied and incentives applied. Naturally, special classes of incentive schemes have to be devised, and it is often impracticable to set one of the better-known systems.

Time study, being a scientific method of measuring labour, can be used in a variety of ways. To gain the maximum advantage from a time study department, clearly it must be used to the full, and if used for the mere setting of rates or time values, the efficiency of time study is reduced to only about 35 per cent.

Here is a list showing some of the various uses of time study.

(1) Setting of time values for use in—
- (*a*) Setting rates for an incentive scheme.
- (*b*) Costing against quotations.
- (*c*) Building a library of "synthetic" rates.

(2) Establishment of standards for—
- (*a*) Ratio of indirect workers.
- (*b*) Machine loading efficiency.
- (*c*) Office and other clerical efficiency.

(3) For use as a measurement of—
- (*a*) Trucking and internal transport.
- (*b*) External transport.
- (*c*) Inspectorate efficiency.

(4) To measure labour costs on—
(*a*) Machine shop and other maintenance.
(*b*) Canteen and ancillary services.
(*c*) Service departments not covered by (*a*) and (*b*).

It will be seen that the uses of time study are comprehensive and can be applied to most of the departments in any industrial organization.

As has been previously stated, time study is not used nearly enough; this is probably due to the lack of experience on the part of the departmental chief, or to a natural diffidence on the part of the employer to extend something which has been invariably associated with rate-fixing. The employer often feels that it is undesirable to use time study for fear of disturbing staff relationship by the implication that the other departments are to be rated! Of course, there is no real reason why this should not be done, but even if the time appears to be not quite ripe for rating, at least the time study department should have the opportunity of setting a correct labour assessment in the other departments. It is obviously uneconomic to save money in the production shops and lose it in the services and indirect labour classes.

Certainly there is a strong case for the reduction of overheads; every employer of labour has come across the problem of deciding exactly what ratio the office and service departments bear in relation to production. Time study can supply this answer.

To analyse the list on page 77, it is found—

(1) (*a*) The need for accurate rating has already been dwelt upon. The main point to be stressed here is that time study at this stage is concerned with setting times on jobs *already running and in production*, i e. the actual setting of time standards is done *after* the job has started, with the result that an alteration in the standards under which the operator has been working will be necessary.

(*b*) This is a forward planning job, i.e. the actual times are not yet available, but in conjunction with (*c*) and by using a "mock-up," accurate labour costs can be supplied, thus removing a great deal of the risk associated with quoting for a contract.

(*c*) A library of "synthetics" will take a long time to build, but once established it can be used to check new rates or to provide the figures for (*b*) with the highest degree of accuracy. The time values in the "synthetic" need to be checked and cross-checked. This is the factor that takes time, but it is well worth it.

(2) (*a*) The ratio of indirect workers such as checkers, progress clerks, and time clerks will be found by time-studying the processes

involved and by setting time values. Since these time values will be tied to production, the fact that direct production is based on a labour quota will automatically establish the correct ratio of indirects to directs.

(*b*) It is perhaps on machine loading efficiency that time study can give its greatest assistance. All machine shop superintendents know from experience the difficulty of assessing the machine loading and being able to rely on it. By having actual time values for every operation, it is possible to ensure the greatest possible output per machine. Further, the actual machine loading operations will be simplified because forecasting is reduced to a mathematical formula.

(*c*) Office and other clerical efficiency needs to be measured. It is human nature for a departmental head to increase staff. It increases his responsibility and sphere of influence, he feels that he is guarding against being overloaded with work; also he is sure that absenteeism will not upset his programme if he is carrying a superabundance of staff. This is where time study can help. The efficiency of the department can be measured by time study and a formula produced that will enable the executives to increase or decrease staff commitments according to production, thereby exercising a very real cost control.

(3) (*a*) Trucking and internal transport is one of the apparently indeterminable features of factory life. Certainly it is a branch of the industry that gives very great scope to time study. Under normal conditions it is practically impossible to measure this, but if time study can actually apply time values to all the parties involved, plot the journeys necessary to supply and remove material to achieve a certain output, recourse to a chart will give the number of journeys required against an alteration in schedule or programme. Such an investigation very often reveals that a number of journeys are unnecessary, and in any case the analysis often reveals economies that improve service.

(*b*) External transport need not be time-studied in the strict sense of the word. The physical act of loading and unloading can be done, but the actual journeying can be controlled by a "master" device, a number of which is on the market. This is sealed and records the number of stops and the length of each stop, thus keeping a constant check on running costs. Even if the above is not considered worth while, the actual measurement of the loading and unloading factors increases the efficiency of the transport system. It is a reasonable supposition that the quicker the turn-round, the greater the actual transport efficiency ratio.

(*c*) Inspectorate has a strong aversion to rate-fixing when it is applied to itself! The usual argument against the applying of a rate is that it restricts the efficiency of the department by causing inspectors to scamp the physical act of inspecting. There is more than a grain of truth in this, but even so there must be a minimum time in which an inspection or testing operation can be efficiently done. To find this, time study can set time values on each individual operation, and even if it is felt undesirable actually to set a rate on the job, at least there will be a measurement of efficiency. Inspection provides an unusually fertile field for personnel increase and needs to be strictly controlled.

(4) (*a*) Of all the services that need a system of measurement, maintenance is the one that needs it most. In many firms the sole criterion of the strength of the maintenance department is the peak period, so that for all the "valleys" on the production chart, the same number of maintenance engineers is retained as is required to perform the task of keeping the wheels turning. Time study can investigate the various times required and can, if necessary, actually set time values on jobs without necessarily applying a rate. This will give the number of people required against the production schedule, and thus again effects savings in man-hours.

(*b*) Canteen and ancillary services such as tea wagons and lunch barrows can be studied by the time study department. An effective control over the canteen methods and personnel, based on known and studied time values, cannot but improve efficiency. The serving of meals in the canteen is one point to be watched. Employees are always appreciative if their waiting time in the queue is reduced!

(*c*) All other service departments, such as stationery, typing pool, toolroom, and drawing office, will yield good results from a time analysis of the functional and productive capacity. There is no reason, however, why time study should not apply its measuring stick to these branches of the factory. They are tied to production. If, for any reason, they are not, then time study will furnish the answer, because it is quite uneconomic and a most unnecessary burden to carry if the numbers of these departments remain constant while schedule and programmes are reduced.

The application of time study standards to personnel other than those engaged on direct production can be accomplished with varying degrees of efficiency, each degree of efficiency being controlled by the standard of measurement that is to be applied.

The assessment of efficiency, as has been demonstrated, is comparatively easy in connexion with direct operators. To those

members of the factory staff who are not actively engaged in directly producing goods, however, the standard of measurement that is to be applied must in a large number of cases be based on a somewhat different foundation than measurement of output. For example, what possible apparent interest can a sweeper in the machine shop have in the number of parts produced by any particular machine? Or to quote another case, what interest can a typist in a typing pool have in the total output of the factory? Yet, if use is to be made of any form of incentive in respect of the above types of personnel, clearly some means must be suggested by which their enthusiasm and acquisitive sense can be aroused. So far, the incentive schemes that have been described have been limited to purely mechanical operations, or those operations where a considerable amount of repetition work is involved.

A standard of measurement can be applied to most of the functional departments of an office or factory. The difficulty lies only in the decision as to what standard of measurement shall be applied or what route shall be followed in the accurate assessment of labour productivity. It is clearly as necessary to decide the methods of determining the results of labour as it is to determine the measurement of labour. It will be realized that in order to assess a standard, either on a group or an individual, it should, theoretically, be necessary only to achieve a correlation between time to perform a job and time actually taken. In actual practice, it will be found that something else is required, that something which in the timing of direct operators is called "Speed and Effort and Skill." To expect the same breakdown in all the indirect operations or sequence of operations is probably aiming too high, first, because of the degree of skill and experience which goes into such jobs as confidential secretarial work, and, secondly, because of the different standards of performance expected from similar people performing similar tasks. An example of this will be seen in the draughtsmen. Two men may be of equal skill and performance, but, owing to the nature of the job, one will take much longer to perform his task than the other. This is understandable, but there is yet another factor. The two men, it has been shown, are of equal ability, the actual amount of work might be the same; nevertheless, despite the expectation that all these things are equal, it will still not necessarily follow that the time factor will be the same. Here, it must be appreciated, the complexity of temperament comes into the picture. Although it might be argued that the presentation of the drawings is the same, yet the fact that two individuals are

concerned mainly with *mental effort* permits the unknown quantity of temperament to creep into the labour assessment.

Despite these obvious difficulties, the application of an incentive can still be made, provided that two fundamentals are adopted in the set-up of standards. These two fundamentals are—

(1) A standard of efficiency must be achieved.

(2) All extra output must be paid for.

The following, which is not by any means a complete list, gives some guidance on—

(*a*) Selecting the standard of measurement.

(*b*) Tying measurement to output.

GENERAL OFFICE

Dependent upon the size of the office, the incentive can be applied either as—

(*A*) On the whole office; or

(*B*) On groups of work-performers.

If the former (*A*) is accepted, then not only must the target be established, but there must be a basic cost in order that savings may be effected.

One way of handling this is as follows—

Setting a Target. It is assumed that the target will be tied to the output of the factory, since it is the assistance that the general office can give that provides the basis for the target. (In the case of sales or publicity departments, the target would naturally be based on the sales curve.)

Taking the output of the factory in hours as X, and the present cost of the general office in hours as C, we divide the cost into the factory allowed hours.

$$\therefore \frac{X}{C} = \text{Factor.}$$

Now this factor, it will be seen, is the relation that the cost of the department bears to the output of the factory.

It is worthy of mention that the time study department might be of the opinion that the personnel could well be reduced, in which case C could be adjusted to cost-potential instead of cost-actual. The factor is used to multiply the cost so that the product will either exceed the target or fall below it. The resulting answer determines the bonus to be paid. Example—

The factory turns out 36,000 allowed hours per week.

The office total hours taken (averaged over a preceding period)

is, say, 5000 hours. It is felt that the work can be done in 4000 hours (not so much of an exaggeration as it seems!). Thus, dividing allowed hours by office hours taken (potential in this case) we arrive at a factor of 9.

Supposing that the factory makes a spurt and increases output to 40,000 allowed hours, and at the same time the office succeeds in cutting its burden by the 20 per cent, we would have—

$$4000 \times 9 = 36{,}000$$

which on the target hours shows a saving of 4000 hours, which is 11·1 per cent bonus on the time taken.

If, on the other hand, the office staff had not succeeded in setting its house in order, then no bonus would have been forthcoming, owing to the fact that the 5000 hours multiplied by the factor of 9 would have totalled *more* than the target hours of the factory. By the same reasoning, if the office hours had remained at 5000 for the extraction of the factor, which would have been 7·2, the bonus would have been the same, but with the promise of even greater bonus if the staff hours were reduced.

Assessing a Fair Day's Work. With (*B*), i e. groups, a much more accurate figure can be achieved. Time study must study the methods and with the help of the motion economist devise more efficient ways of doing the job; then by rating the Speed and Effort and Skill, a time limit can be given. (For certain jobs such as daily filing, entering of records, and statistical charting, it is better to make the standard a daily one, i.e. so much time allowed in the day, plus relaxation, will give a *fair* day's work.) Then it must be *assumed* that the output in hours has been maintained This throws the responsibility on to the supervision. But this is more recommended than engaging in expensive checking methods. It will be observed that in these cases the opportunity of making bonus is reduced; in other words, it is assumed that with more efficient working and application to the duties a rating efficiency will be achieved. This can be set at an "80" or "75" according to how much labour has been saved by applying the rate.

In the case of typing pools, there is an entirely different set of circumstances.

This section is divided into three—

(*a*) Copy or invoice typists.
(*b*) Shorthand or voice recording.
(*c*) Secretaries with (*b*) and other duties.

In the case of (*a*) this can be time-studied. In the typing of

invoices, there is usually a standard form, a standard presentation and little variation in context. So that it will be fairly easy both to time study and to check output. (This latter can be done by supervision.)

With (*b*) a slightly different technique is employed. If it is decided to use shorthand writers then there will have to be a grade. The grading can be based on the Pitman Shorthand Certificate or the R.S.A. The reason for this will be apparent when it is realized that if a shorthand-typist is particularly skilled, she should be paid for that skill as distinct from output. It may well be that she can take down at 200 words per minute, but few people can dictate at that speed for long.

Grading can be done on the S.E. rating by offering a compensating factor. For example: If a typist brings a certificate to the effect that she can take down at 120, then she would be entitled to a plus rating of 15. So, in effect, if she is rated at 65 for transcribing and typing, in actual practice if she works at this speed of 65 she will be paid on an 80.

Where voice recording is in operation, this is a different category entirely. All the typists then are based on a common denominator, there being no variant as there is with shorthand. With the voice recording unit, the speed of the cylinder can be adjusted to the typist's own capabilities for typing. Service labour should be employed to "shave" the cylinders and perform all the functions of "fetch and carry."

Proving Output. A checker will be required to record the output of the typists; one of the best ways of calculating the output is to have a small frame made up with a frosted glass surface, having a lamp under the glass which is scored at normal double or single spacing (according to established custom of presentation), so that the letter can merely be laid on the frame, thus making it very easy to assess exactly how many lines of typing have been done, the target being established on "lines per hour." In both of the above classes, a fairly high fatigue ratio will have to be given in order to compensate for the extreme degree of concentration required.

With (*c*), secretaries, a different technique will have to be followed. Certainly the target cannot be tied to the output of the factory; neither can the job be time-studied. Since secretaries, however, are paid for discretion in a large number of cases, it seems as if this class will be best covered by a lieu bonus, based on the average of the general office (to safeguard against work being "farmed out").

WAGES AND COSTS DEPARTMENT

The target here is obvious. It is the number of direct and indirect employees' hours that have to be computed. A scheme carrying a formula similar to that described for the general office will give the desired incentive.

FACTORY INDIRECTS

In most cases, as these ancillary functions are tied to the factory, the use of existing targets will simplify matters. For instance, the use of the group system presents group targets, and, quite obviously, feeders should be included in the group's target figure

TOOLROOM

There are three alternative incentives for this department—

(1) Estimating.
(2) Factory output target.
(3) Group target where applicable.

(1) This is the most favoured. It is accomplished by having a toolroom estimator who estimates the time allowed for each job, and the toolmaker then clocks on the job just the same as an ordinary production operator, checking being done by a tool inspector, toolroom supervisor, or the departmental supervisor requesting the tool.

(2) This is usually employed where there is some doubt as to the advisability of using an estimator. In any case, in the small organization, the employment of an estimator is not warranted. A formula, an efficiency formula, is required where this scheme of target fixing is employed.

Few toolrooms can be considered 100 per cent efficient, and the rating factor is one that should receive the most careful consideration. If it is decided that the rating is less than 100 per cent efficient, then the following formula can be safely applied.

Let X be the target (total works output).

Let C be the average hours spent.

Let the efficiency rating be according to judgment; for example, 80 per cent.

$$\therefore \frac{X \times 80}{C \times 100} = \text{factor.}$$

Thus the factor multiplied by the hours actually taken will bear a relationship to the works output and so permit a bonus calculation.

(3) Some toolmakers can be effectively tied to a group's output. This particularly applies to such toolmakers as those who prepare

the dies for die-casting and the moulds for Bakelite work. Again, a ready association will be seen on those tools used for blanking and certain forming operations.

In cases like those described above, the tying of the toolmaker to the output of the group is an incentive towards efficient service.

MAINTENANCE DEPARTMENT (PLANT)

In this case, it is unwise to try to control the hours spent in servicing. If steps are taken to reduce the labour by simply stepping up speed of servicing, then routine inspections of machines will probably be scamped, with unfortunate results to the machine loading control. No, in this case, it is better to adopt the positive angle and pay for good servicing with a penalty for bad servicing. For instance, a grading system of faults-classification can be instituted whereby the faults, if traced to the maintenance staff, will be debited against their share of bonus. In other words, a points award system is set up. The total machine hours are assessed and plussed for efficiency. Supposing the existing load was 59 per cent due to poor loading, poor service, and machine breakdown. Then the points value would be tied to the present inefficiency, e.g. total inefficiency 41 per cent, of which 22 per cent is due to machine breakdown.

Now, each machine is valued according to prime or capital cost and its need in the shop. Taking a simple example—

Machine	Value	Loading Factor per cent		
No. 2A Ward	300	80	A	Points value based on amount of skilled labour required to service machine to maintain efficiency
No. 0 Herbert	250	64	B	
Drill press	30	72	C	
Guillotine	400	32	D	
40-ton press	600	28	E	
90-ton press	800	25	F	

A has the highest efficiency but a medium cost; since there must be a basis for comparison, take the total man-hours employed in the plant department, and use this to establish the "point" value.

So the formula is—

Let value be V.
Let load factor be LF.
Let man-hours be C.

$$\frac{V \times LF}{100} = x. \text{ Therefore } \frac{c}{x} = \text{points value per hour.}$$

It will be seen that this correlates the percentage efficiency to the value of the machine, which is necessary, due to the fact that the higher the cost and the lower the efficiency, the greater becomes the loss-potential to the firm. So a method such as this ties up the capital expenditure value to the machine life, which has obvious advantages.

Applying the formula to the sample list on page 86, we find—

A. $\dfrac{300 \times 80}{100} = \dfrac{(1000)}{240}$

$= 4{\cdot}166$ points per hour at 78 per cent efficiency.

100 = 5·3 points per hour.

B. $\dfrac{250 \times 64}{100} = \dfrac{(1000)}{160}$

$= 6{\cdot}24$ points per hour at 78 per cent efficiency

100 = 8·05 points per hour.

C. $\dfrac{30 \times 72}{100} = \dfrac{(1000)}{21{\cdot}6}$

$= 46{\cdot}5$ points per hour at 78 per cent efficiency

100 = 59·8 points per hour.

D. $\dfrac{400 \times 32}{100} = \dfrac{(1000)}{128}$

$= 7{\cdot}45$ points per hour at 78 per cent efficiency

100 = 9·58 points per hour.

E. $\dfrac{600 \times 28}{100} = \dfrac{(1000)}{168}$

$= 5{\cdot}95$ points per hour at 78 per cent efficiency

100 = 7·62 points per hour.

F. $\dfrac{800 \times 25}{100} = \dfrac{(1000)}{200}$

$= 5{\cdot}0$ points per hour at 78 per cent efficiency.

100 = 6·42 points per hour.

As the plant personnel have been allowed 1000 points, i.e. 1000 hours, in this example it follows that the longer the job takes to repair, the greater will be the debit on points and thus less bonus can be made. The fact that the points-debit has been advanced 35·4 per cent from an efficiency ratio of 78 to 100, is to take care of the inefficiency ratio shown by the machine loading control.

The personnel book on the various jobs in the same way as direct operators but, instead of quoting job numbers or part numbers, the machine description or number is quoted instead, thus making it

easy to correlate the time allowed. At the end of the week all the debit points are totalled and, if they amount to less than the allowed hours, that is, 1000 hours, bonus is payable on the difference or "time saved."

Dependent upon the efficiency of the machine loading control and the size of the shop, whether or not a "protective" margin has to be created, a few adaptations of the above formula will soon prove this point.

What at first sight appears to be a paradox, the high points value of the comparatively low-priced machine, can be explained by the fact that loading factor is high, and, further, it is inadvisable to have a high points value for the more expensive machines for fear that the work will suffer, and the repercussions on the higher-priced machine are obvious. Further, the drill press has little to go wrong, and takes less time to repair.

There is but one other point to consider. Mention has been made of the periodic servicing of machines. This should be delegated to second-grade labour, and the labourer will share in the bonus of the plant department. It is to his advantage to keep the machines oiled and free from chips and swarf in the running parts. Clearly, if breakdowns occur, due to chips penetrating to the bearings, this will detract from the efficiency of the plant department and thus cause a loss in bonus.

In many organizations the carpenter's section is considered part of the plant engineer's department. This is probably its correct location, but, for the purpose of an incentive, it should be kept separate, and if the organization permits it, the work should be estimated and job cards or work tickets issued to cover the estimate.

INSPECTION

There is a conception amongst the inspectorate that they, as workers, are beings apart from the rest of the factory. Managements in many instances seem to share that viewpoint. There is no reason why the inspection department should not be placed on an incentive scheme. Where it has been applied it has worked very well, and if the department can be placed on a "direct" incentive as distinct from an "indirect" incentive, then a great many benefits will accrue.

The assumption that inspectors cannot be placed on a "payment by results" scheme is based on the impression that the inspectors will become too casual or relax their limits to the detriment of the quality of the work. This is a fallacy. It has been proved conclusively that where a direct scheme of incentive has been properly applied,

the standard of work certainly has not deteriorated; if anything, it has gone up. One of the immediate benefits has been that labour requirements have shown an improvement, through the application of *controlled* ratings.

Valuing the Inspectorate. When it is considered what a high burden inspection comprises in the cost of an article, it will be readily appreciated that any steps that can be taken to reduce this overhead must inevitably react favourably on the cost control and also on operator-efficiency. This latter is not necessarily a trite remark; too many inspectors, like too many cooks, spoil the product. There is no reason why inspection should not be rated the same way as direct operators. The output of the inspection department can be based on so many pieces per hour and rated accordingly. Inspection, because they occupy a position of some responsibility in regard to the finished product, should have a penalty clause attached to their rate. This is how it works. Supposing the time study department has studied a job and has come to the conclusion that one inspector can inspect and pass or reject so many parts per hour, this is the target that is issued. The reader should observe most carefully that the target will include parts rejected. This is an easily computed sum, because the rejection analysis sheets, which all organizations should keep, will reveal how many parts are rejected, and the information as to how many are passed will be thrown up in the normal way. The target is set accordingly, and the leading hand, who is paid a higher rate than the ordinary inspector, is responsible for percentage-checking inspection's work; in other words, if one leading hand is responsible for ten inspectors and does a 10 per cent inspection of their work, the time involved will be sufficient to keep a leading hand fully occupied. Because the leading hand is not on an incentive scheme, he is paid a higher rate, and it naturally follows that he will be immune from the "desire to scamp his work." If the percentage inspection reveals a flaw, then the whole batch is returned to the inspector concerned to be re-examined. This means that he will take longer over the job and this will have an adverse effect on his bonus earnings. This is a very effective way of controlling the inspector's work, and at the same time will ensure maximum efficiency. It should be realized that the inspectorate is invariably one of the most overgrown departments in a factory, and the introduction of time study rating into this department can mean the saving of anything up to 50 per cent personnel, which more than repays the cost of the incentive scheme for that department.

PRODUCTION OFFICE

Where it is found that the production office can benefit from the introduction of an incentive scheme, the target as set will be somewhat intangible, due to the fact that it is difficult to assess the output of the creative type of worker. However, as in all cases, there must be an average of some description, whether it is purely a question of time or a standard of work; and in the case of the junior draughtsmen, who, in any case, work under the control of a senior draughtsman, the work in this respect is more likely to be mechanical. It will be sometimes possible to tie the output of draughtsmen with the output of a shop or group of shops with which they are concerned. The same remarks will apply to junior clerks, progress chasers, statistical workers, junior time study staff, etc. Progress chasers, of course, can be tied very effectively to the output of the particular department or shop, but it is difficult to reconcile this factor with the work produced by the junior time study staff and the statistical department. So, arising from the foregoing then, there are two distinct conditions—

(1) Where it is possible to tie the output of a worker to the output of a particular department; and

(2) Where it will be necessary to tie the output of a worker to the output of the factory.

Measurement of output from any of the above causes will present some difficulty, and until adequate data (*re* performance, etc.) have been compiled, it might be worth while to ignore the question of output altogether and concentrate purely on the number of people employed in the department (or, to bring this factor to a finer degree, the number of hours spent by the people), and use this as a common denominator. For example, in (1) let us assume that the output in allowed hours produced totals 11,500 hours per week, and the incentive participants work during the same week 200 hours, i.e. five junior draughtsman working 40 hours each would peg the incentive rate to these figures in a similar manner to the "factorization" formula. An alternative suggestion which comes to mind is that a target mean is established (done by averaging out previous six months' totals) which might total 10,000 hours. We have established that the figure produced in a week was 11,500, thus showing 15 per cent increase on the standard, and leaving then 15 per cent bonus hours to be added to the 200 hours spent on the job. This is a very general and loose scheme, and it can be applied purely as a means of offering a "carrot," but the discerning reader will immediately see that it is not a reflection on the efficiency of the

draughtsmen, since clearly they could have spent 300 hours during that week and still receive 15 per cent bonus. So, as incentive schemes are primarily designed to increase efficiency, in other words, reduce the time taken to perform a certain function, it is obvious that the first suggestion is the better one.

TRANSPORT (INTERNAL)

Internal transport, composed of truckers, liftmen, feeders, dispatch department, etc , should be tied to the factory output. This is done by the same method of factorization as previously done for the toolroom and general office.

It is not considered desirable to rate the efficiency of the liftmen, although there is no reason why it should not be measured; nor is it desirable to rate the truckers. The reasons against these two sections being tied to a "local" target is that there will be a tendency to make the work fit the target, instead of making the target fit the work. This imposes delays upon goods that might be in high priority. For instance, the liftman, if his target is based on weight (as it would be), will show a tendency to wait for an accumulation of material before completing the errand (again as he should); this will have an adverse effect on the servicing between floors. On the other hand, if the rating efficiency or the target is set on journeys, there will be yet another tendency to cut weight and bulk in favour of journeys, with the result that the power consumption will be needlessly increased, and the wear and tear of the transport machines correspondingly greater without a correlated increase in traffic.

The truckers who serve a group, or shop, can be tied to the output of that group or shop; the liftmen, however, will have to be tied to the output of the factory.

In the case of the factorization, it would be better to consider taking the whole of the trucking department personnel instead of relating the truckers to a specific group.

In the one case, there is the question of labour assessment, it being patently more difficult to reduce truckers assigned to a group without impairing that group's service; in the other case, the amalgamation of all trucking services means that a duplication of interests can take place without upsetting the bonus calculations.

In the case of the group, the issue is a personal one to the trucker; in the case of the factory target, it is less real but means less supervision and greater flexibility.

TRANSPORT (EXTERNAL)

This is a job that can be rated. The actual physical part of loading and unloading can be rated according to—

(*a*) Weight only.

(*b*) Weight plus bulk.

The variables here are controlled solely by the merchandizing in which the firm is engaged.

To the factors of load and unload (bearing in mind that skill is evidenced by good packing and stacking) governors are brought into play which record the travel of the lorry and its idle time. Thus it is easy to assess a target for this section. Care should be taken to allow sufficient time for the journeys, otherwise the Traffic Acts might be violated, and this would rebound upon the good name of the firm.

SETTERS

On page 46 it was shown that a setter who was also an operator could be rated on *productivity* but not on his setting ability. It was pointed out that the way to control this factor was to have him book on a special code number for his setting time.

In the case, however, of a setter responsible for a group of machines, some incentive must be applied to make quite sure that he will set the machines with the utmost dispatch in order (*a*) to give the operators maximum service, and (*b*) to increase the load factor on the machines.

There are at least two ways of accomplishing this—

(1) By permitting the setter to share the group's bonus, being paid a percentage bonus according to the group's earnings.

(2) By being given a compensation factor and actually booking his hours against the group and thus receiving the same bonus as the group.

In (1) it will be seen that there is no control over the setter's time; he will receive a *pro rata* bonus according to the group's earnings. Usually this is done by assuming that because of his skill his base rate will be higher and thus, if bonus was paid at the same percentage as the group, he would receive much more for his efforts.

To prevent invidious comparisons, it is found better to control his earnings, but at the same time to leave sufficient incentive. This is done by discovering by what percentage his base rate exceeds the average of the group and by paying him anything over that figure. For example, supposing the setter gets 1s. 6d. per hour, while the operator gets 1s. 3d.; thus the setter is in receipt of 20 per

cent more than the operator, so the setter would receive bonus only in excess of 20 per cent of the group earnings. So if the group made 15 per cent bonus, the setter would receive no bonus, but if the group made 30 per cent, the setter would receive 10 per cent, the difference between 20 and 30 per cent.

In (2) there is a different arrangement. Because the setter is going to book on the group and thus be effectively tied to that group, the incentive should be made greater. It is in the interests of the setter to see that the group as a whole produces more parts per hour, so he will be expected to work harder and thus should receive a much greater reward. Again, because of his intimate interest in the group's output, he will work to assist in the supervision, by checking rejects, reducing scrap, and using his personality in the interest of labour.

For these reasons, even though he is in receipt of a high base rate, he should receive his full share of the bonus earned by the group. His interest in the group will, therefore, be maintained to the benefit of both the operators and the firm.

In booking on the group, he will be penalizing the operators because he will not be actively *producing* parts. In order to remove this burden, the group's allowed hours are compensated by the hours spent on the group by the setter.

EXAMPLE

8 operators at 45 hours	=	360
1 setter at 45 hours	=	45
Total time taken	=	405
Total allowed hours produced by 8 operators	=	470
Plus time taken by setter	=	45
		515
Percentage bonus earned by group (standard time)	=	27·0 per cent

Working out the bonus that would have been earned by the group if the setter had neither been booked on the group nor credited with his hours, it is found—

Time taken by group	=	360
Time allowed to group	=	470
Percentage bonus earned by group	=	30·5 per cent

This difference is obviously accounted for by the fact that while every hour of the operator is capable of bonus-potential, the setter's hours credited to the group are net and incapable of being "plussed" by bonus-potential. This indicates that the setter's hours credited must either be "loaded" or compensated in some way. The fact that the setter is also working for the good of the firm, inasmuch as he is safeguarding wear and tear, sharpening tools, and generally looking after machines (expressed as capital expenditure), indicates that the firm should bear some part of his cost of extra effort. This can be done by assuming that the hours chargeable to the group for bonus purposes should be reduced as a measure of reward.

An alternative is to "load" the hours credited to the group to compensate for the lack of bonus-potential.

In the first instance the setter's time *debited* to the group would be reduced by 20 per cent, thus permitting normal bonus to be made by the group.

In the second instance the setter's time *credited* to the group would be increased by 33·3 per cent, which has the same effect.

CANTEEN

Mention is made of this particular ancillary function for the very good reason that it plays an important part in the habits and welfare of the worker. It is to the benefit of both worker and management to have a well-run and well-patronized canteen. Since most canteens are subsidized by the firms concerned, the number of meals served plays an important part in percentage or profit/loss, and, naturally, if the meals consumed can be increased by means of (*a*) better presentation, (*b*) rapid service, then it follows that the profit/loss can be maintained. This then is the reason for considering the need for an incentive scheme in the canteen.

How can it be employed? Most certainly the time study and methods departments should be able to look over the system in order to investigate in what direction improvements can be made. Having indicated the directions in which improvements can be made, the point now remaining for settlement is the method of applying the incentive.

The first thought that springs to mind is that the incentive should take the form of time taken against meals served. At first sight this seems to be obvious, but a moment's reflection will reveal that this is difficult to calculate. What constitutes a meal? A large number of employees will want to bring sandwiches and merely buy a cup of tea or coffee. Does this constitute a meal? Again, a large number

of organizations send round tea wagons during the afternoon break. Do these services qualify as meals? So it will be seen that to tie the target to the number of meals served is no real guide

A target that is chosen must be capable of easy assessment and must be as nearly foolproof as possible. There is one target in a canteen that is foolproof, and that is the cash that is handled. In this there is a ready-made target assessment which *has* to be right Since the aim of the canteen committee (in the case of organizations with the right democratic ideas) is to increase the turnover, here is the real incentive. The target can be tied to the cash taken and thus be correlated directly to the amount of work performed, in order to obtain that money.

A scrutiny of the books over the preceding year or six months will reveal the average amount taken weekly. The same scrutiny will also reveal how much staff was required to give the service. This then will provide both the target figure (which needs to be beaten) and the average time taken, in hours (which needs to be reduced).

The Target. To set the target. Assume that the average takings total £300 per week, for which a staff of seven is required. Thus, 7 at 42 hours = 294 hours, and 294 hours produced £300, so that each hour is equivalent to £1·02 approximately. So that from this figure it is easy to calculate how much bonus shall be paid when the figure £1·02 is increased. In order to give an immediate incentive, it might be necessary to "load" this figure, say by 10 per cent, so that the zest for increasing might be germinated.

CHAPTER VIII

SELECTION AND TRAINING OF TIME STUDY PERSONNEL

THE problem of training time study men is an ever-present one. The recruitment of personnel from outside the organization has its good points; the introduction of fresh blood into management is always a good thing, providing that such introduction is done wisely. However, many organizations prefer to train their own time study personnel and the recruitment of these is usually done from the works.

Certainly the aim of management should be to catch them young! Not so young that they will lack maturity, but young enough to be able to have some sort of elasticity of outlook. This acceptance of fresh ideas is important in time study work, bigotry should find no home in the time study department.

There are several methods of training time study observers. Most firms which have experimented with this selection and training have found to their chagrin that the finished product is invariably not so efficient as the existing personnel. This is due to the form of training, most of this training being merely a period devoted to the department's clerical section in order to learn the formulae and then assigning the trainee to an experienced time study observer with the vague idea that the trainee will "pick up" the work.

Other firms send the trainee round the shops for some months with different observers in order that the trainee will absorb different aspects of the work.

Both of these methods are incomplete. They do pay sufficient detail to the *basic* training; but they do not ensure that the trainee *understands*.

Here is a suggested outline of a training scheme based on actual experience. It will not turn out *qualified* time study men. It will turn out, however, men who have a thorough understanding of what time study is and its scope. Then, following such a training course, it is suggested that the trainees should be assigned to an experienced observer. Constant practice can then be maintained until such times as it is considered that the initiate is sufficiently trained to take up such responsibilities for which his experience and training fits him. The rest is pure experience.

It is suggested that the group of selected trainees should not be

large. If the scheme is too ambitious, the personal touch, which is so valuable between the instructor and the pupils, will be missing,

It will be seen that a training department or school is desirable. This point is stressed because, if the fullest value is to be extracted from new operators, then some sort of pre-training is necessary, hence the strong association of ideas in connexion with the training scheme for time study personnel.

Selection tests are mentioned in the syllabus. The Institute of Industrial Psychology has prepared certain "personnel selection tests" which have been proven of great value. It is meet, therefore, that the participation in these tests by the time study trainees should be insisted upon, if only to assist in the elimination of the dead wood.

The qualifications necessary in a time study observer have already been touched upon, and what remains is to decide from what source to recruit the trainees.

There are several sources—

(*a*) From within the framework of the organization.

(*b*) From external sources.

(*c*) Direct from university or training college

All three sources should be explored; (*c*) by reason of the presupposed greater intellectual attainments should prove a fruitful field, but if this is decided upon, it is wiser to insist that the trainees shall work in the factory in order to become accustomed to the atmosphere and working conditions—six months should not prove too long.

If (*b*) is the deciding factor, then advertisements or the labour bureaux should provide the material.

With reference to (*a*), this should be done with care. Operators, no matter how good they are, are apt to prove a disappointment when promoted to the time study department. Their own experiences are likely to prove too much of a guide, whereas the ideal aim is surely to render the study of work a scientific matter. Chargehands or foremen will be the main source of supply, but some craftsmen, such as toolmakers, will probably be helpful. It is reasonable to assume that the clerical grades of factory workers, such as process planners or progress chasers, also will provide a useful field from which to recruit.

BREAKDOWN OF SYLLABUS

It will be observed (Fig. 21) that the syllabus is produced for "advanced" trainees. This is designed for the benefit of those who

have had the advantage of being passed through a training department or preliminary training period for machining and assembly; it is, therefore, assumed that they are cognizant of the factors involving clock cards, bonus, rates of pay, hours, three- and two-shift systems, etc. They should also be able to read a vernier, micrometer; use height and depth gauges; and have a working knowledge of the decimalization of inches and hours.

The syllabus, it will be seen, is broken down into thirteen weeks. Each of these is loosely divided into ten sections. Every week commences with "report write-up" and finishes with a résumé of the week's work. The reason for this is that notes taken during the week's work, at the best, can only be sketchy, and allowing time on the Monday morning for a more complete write-up, gives the subjects that have been taught more opportunity of being mentally digested.

In this diagram each week has been designated by a letter for easy reference.

(*a*) First Week

1. Introduction. This deals with the reason for the course and the need for high standards, careful training, etc. At this moment emphasis is laid upon the fact that there is no guarantee that the trainees will necessarily be admitted as time study observers and that it all depends on their own efforts. They are also told that a monthly report of their progress will be submitted by the lecturer to the Management, but that they themselves will have a copy of this. This provision removes any fear of bias.

(2) Then follows a short description of the organization as a whole. A Management Chart is projected on the blackboard and the trainees are given copies of it. The breakdown of the various sections follows and the difference between the direct and indirect departments is clearly shown. The goods that are being produced are quickly run through, and all the while emphasis is laid on the importance of maintaining schedules. The correlation of incentives to production is illustrated at this point.

(3) Then follows a tour of the branch factories (if any) and the main factory. Usually a day is spent on this. Arrangements should be made beforehand with the various shop foremen in order that points of interest can be brought out. It may be that there is a special process which occurs only once a week and efforts should be made to synchronize this with the visit. (Hence the need for elasticity.)

SYLLABUS OF TRAINING FOR ADVANCED TRAINEES

Introduction	Factory Organization	Branch Factories	Ele Industrial Economics	How to Write a Report	Intelligence Test	Elementary Maths	Slide Rule	Safety Engineer	Resume	1st Week
Report Write-up	Elements of Motion	Lay-outs, etc	Wages and Tabulations	Process Lay-outs	Formulae and Practice	Elements of Motion	Element Writing	Forms Study Sheets	Resumé	2nd Week
Report Write-up	Maths Practice	Bonus Queries	Element Breakdown	Maths Practice	Talk by Cost Dept	Graph for Stop Watch	Visit to Wages	Visit to Tabs	Resume	3rd Week
Report Write-up	Explanation of Stop Watch	Practice with Watch	Elements of Motion	Practice	Graphing Error	Practice	Graphing Error	Practice	Résume	4th Week
Report Write-up	Practice	Graph Error	Practice	Graph Error	Practice	Graph Error	Talk on Management	Practice	Resume	5th Week
Report Write-up	Elements of S E	Practice	Talk by Personnel	Speed Dems	S & E Practice	Travel Dems	Travel Dems	Travel Dems	Resume	6th Week
Report Write-up	Travel Dems	Travel Dems	Travel Dems	S & E Practice	Check with Rates	S & E Check	S & E Check	S & E Check	Résume	7th Week
Report Write-up	S & E Practice	Tab Queries	Stop Watch	S & E Practice	Stop Watch	S & F Check	S & E Check	Stop Watch	Résumé	8th Week
Report Write-up	Practice Investigation	S & E Practice	Stop Watch	Clock Card Reading	S & E Practice	Stop Watch	Speed Measurements	Effort Measurements	Résume	9th Week
Report Write-up	S & E Practice	Talk on Die-casting	Stop Watch	Talk on Bakelite	S & E Practice	Stop Watch	Talk on Cutting Tools	Graphing Error	Resume	10th Week
Report Write-up	S & E Practice	Stop Watch	Check Studies	S & E Practice	Stop Watch	Motion Study	Motion Study	Motion Study	Resume	11th Week
Report Write-up	S & E Practice	Stop Watch	Check Studies	Motion Study	Stop Watch	Check Studies	S & E Practice	Motion Study	Resume	12th Week
Report Write-up	Visit to Lay-out	S & E Practice	Visit to Planning	S & F Practice	Stop Watch	Check Studies	S & E Practice	Complete Course	Resume	13th Week

FIG 21

It should be appreciated that the above syllabus although divided into thirteen weeks is not intended to be an accurate guide as to the division of time spent on particular subjects When this was designed it was done with the sole idea of making it as elastic as possible

(4) Then follows a short talk on industrial economics in general and domestic economics in particular. It is here that the need for incentives is driven home. The question of labour cost is discussed and the example of the percentage of labour to production is clearly demonstrated. Base rate is discussed, also the various comparisons of piece rate, bonus rate, flat rate, and the different methods are clearly shown.

(5) A considerable amount of time is devoted to "How to write a report." This is important because right through the time study observer's career there will be a dominant need for accurate and efficient report writing. The various facets of this subject are dealt with, particularly in connexion with a change of method; introduction (i.e. change of method); précis of previous method: suggested new method; cost of old, cost of new; saving over one month, one year, two years, according to the contract and the number of man-hours that can be saved

Attention is paid to graphs, charts, and every opportunity is given in subsequent training periods for constant practice in this subject.

(6) The intelligence test is usually run in conjunction with the training department. It will be found necessary sometimes for the time study lecturer to run this; but it is considered desirable that constant conditions and atmosphere should exist in order that fair comparisons can be made. During this period, facilities should also be given for the "special aptitude" test to be given. This is not necessarily valuable in view of the fact that the time study observer does not need to be particularly dexterous, but its value lies in the need for the "standard results" to be added to, and, since the trainee should be of a higher mental development than the operators taking the test, obviously some valuable information is revealed for "domestic use."

(7) Elementary mathematics. This is primarily a test. If the trainees are "rusty" they must be quickly brought up to standard. It is during this period that the slide rule is introduced. If the trainees do not know how to use it, arrangements are made for them to take special training. Formulae are practised and the need for memorization of these is laid down.

(8) Towards the end of the week the trainees are passed over to the safety engineer (if one is available) for a few hours. He takes them round to the shops demonstrating the various aspects of his work. He draws attention to the special regulations governing milling machines, presses, and degreasing plant. It is his job to

impress upon the trainees the need for looking for danger hazards and their responsibility for reporting all hazards, and also that they are forbidden to study a job which appears to possess a hazard.

(9) The résumé is given by the lecturer and covers briefly all the foregoing points.

(*b*) SECOND WEEK

(1) This is commenced by a report write-up. The lecturer leaves the trainees quite alone for this, since it will be his aim to lead the trainees along the path of independence. Naturally if assistance is given during the report-writing stage of the training, much of the value of the lessons will be lost, because the trainees will come to rely too much on the lecturer.

(2) A whole morning is devoted to the elements of motion economy. This is not meant to be an exhaustive lecture, but merely serves as a thought-provoking introduction. Demonstrations are given with a mock-up of a bench assembly unit. A talk is given in which various examples are either actually produced or projected on to the blackboard. It will be found that if actual time factors are given, these will have a greater appeal than mere generalizations.

(3) An introduction to the methods employed by the methods department is given by one of their staff. Methods employed to obtain service are demonstrated by the use of the paper work

(4) The talk is followed by a visit to the wages department which experience shows needs quite three hours. The trainees should be taken down and introduced to the manager, and he will pass them over to a member of his staff The trainees see the various methods employed to determine the bonus earned, the computations, and the department's mechanics.

(5) They then pay an actual visit to the methods department, who show them how the various operations are dovetailed into a whole. (This, following the visit to wages, enables the trainees to see the workings of the operator-per-group relationship.)

(6) Time is now given to the practising of formulae by means of examples written on the blackboard. This is based on the calculations that will follow on later in the course, e.g. the examples will merely consist of the reconciliation of the time and speed and effort factors, thus—

$$\frac{\text{T.} \times \text{S.E.}}{60} = \text{Normal seconds}$$

A large number of examples will be available in order that speed

as well as accuracy may be readily attainable. Factorization will also be shown.

(7) A further talk is given on the elements of motion economy, and in this instance the students are given the opportunity of re-designing an old lay-out. The model, blue-prints, schedule, and number of operators are all supplied and the trainees are left to work out their own methods. This is then followed by a discussion, and the proven methods are then described in order that adequate comparisons may be made.

(8) The students are then introduced to element breakdowns and writing. They are shown the need for correct descriptions. This is followed by a test. The instructor performs a sequence of operations, and the students write up their conception of the element breakdown Following this, the instructor endeavours to perform the same functions by faithfully following the write-up. This is most instructive and drives home the lesson very thoroughly. The faults are clearly shown up by this method.

(9) During this lecture the trainees are introduced to the various forms and paper work involved in the efficient functioning of a time study department. They are made cognizant of the time study routine from beginning to end. They are shown how to handle the queries and how to make adjustments.

(10) The résumé is given by the lecturer and covers all the foregoing points.

(*c*) THIRD WEEK

(1) The third week commences with the report write-up. By the time this stage is reached the trainee should have a good idea of the way the report needs to be written, and all the previous mistakes should be well on the way to complete elimination. It may be necessary to spend a little time with each trainee in order to iron out any difficulties which to the student appear insuperable.

(2) More practice in formulae, this time to ensure that the slide rule technique has been well and truly absorbed. The stage in time study computations can be advanced to include the working out of bonus earned from: Parts produced in the time taken divided by the rate in pieces per hour (standard times).

$$\therefore \frac{\text{P.P.}}{\text{T.T.}} = \text{Pieces per hour}$$

$$\text{thus} \quad \frac{\text{Pieces per hour} \times 100}{\text{Rate}} = \begin{array}{c}\text{percentage of time payable}\\ \text{at base rate.}\end{array}$$

(3) Some considerable amount of time is spent on bonus queries. The number of queries depends upon the efficiency or otherwise of the time study department, and it is essential that the trainees should be fully aware of (*a*) how caused; (*b*) the remedy.

Care is taken to explain the various causes of queries, and time is profitably spent on analysing the various methods that can be adopted in overcoming the errors. This is the time to explain the reasons for excessive bonus being earned, the need to check up with the progress planning department on the methods to be adopted to avoid wrong booking. Examples are quoted.

(4) More time is devoted to element breakdowns. The need for correct writing up of each hand (and foot) is reiterated. Examples are quoted where it has been found impossible to check an alteration in method solely due to the fact that the elements were not previously correctly noted.

(5) Still more time is given to formulae. In this case the students go a step further and show the formula for discovering the bonus earned given the time allowed and the time taken (standard times). Example—

Let time allowed be TA
Let time taken be TT
Let time saved be TS

Therefore $TA - TT = TS.$

$$\frac{T.S.}{T.T.} \times 100 = \text{per cent bonus.}$$

To find the time allowed, take rate and multiply by parts produced divided by 100.

(6) Then follows a talk by the works accountant. This deals with the firm's relations with the various selling organizations Emphasis is laid on the need for accurate estimating (responsibility, in part, of the time study department). Examples are given where it has been found possible to reduce the quote after it has been submitted.

(7) A graph is prepared for the recording of the stop-watch error, this is shown in Fig. 22. The purpose of this is to provide a picture of the trainee's tendency to error. The trainee is considered reasonably efficient when the readings on the graph remain constant to within 4 per cent. The optimum is 2 per cent, but due allowance must be made for complexity of operations.

(8) The trainees now pay another visit to the wages department and to the tabulating department for the purpose of refreshing their

memories and co-ordinating the points described at lectures. This covers bonus queries, booking of operation, and part numbers, the checking of clock cards, etc.

(9) The résumé is given by the lecturer and covers all the foregoing points.

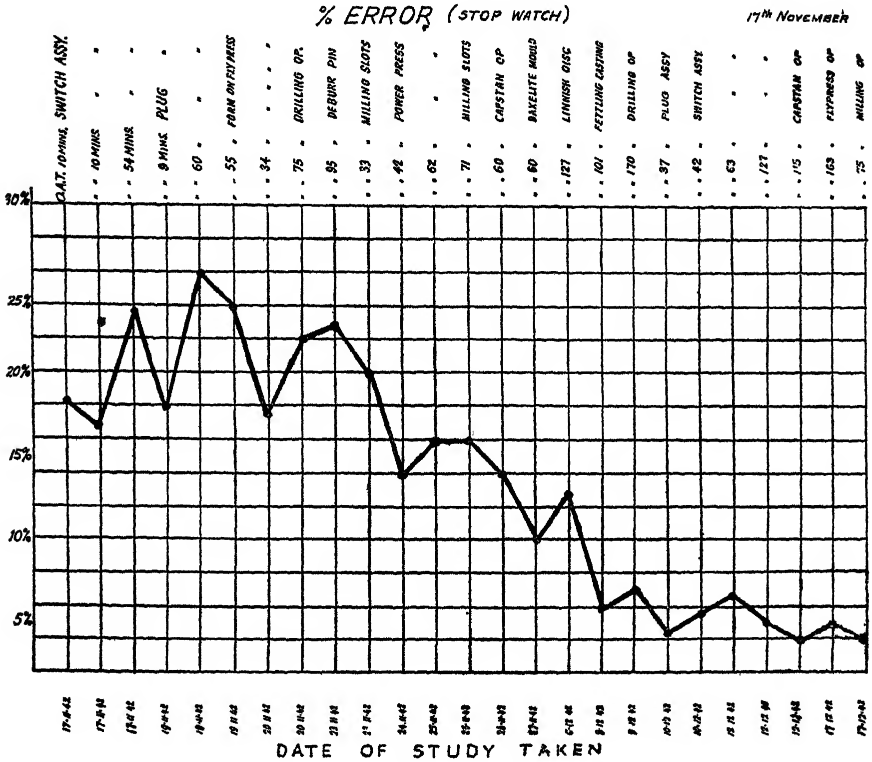


FIG. 22

The graphing of percentage of error in stop-watch recording is of considerable value, because it gives a clear picture of the progress being made by the candidate, and at the same time spotlights the weaknesses inherent in all inexperienced observers. For instance, it will be seen that after the relatively simple stop-watch study of Bakelite moulding, the comparatively fast study of linnishing is brought a degree of inefficiency.

(*d*) FOURTH WEEK

(1) The fourth week commences with the report write-up and the trainees by now should have sufficiently advanced to handle this entirely on their own.

(2) The fly-back stop watch is explained to the students The methods of setting and checking against a "master" is described. The students are shown how to hold the watch and control its mechanism. They are warned against using it without a safety-thong. They are told that it must not be left running during the day unless being checked, but that it must be left to run down overnight in order that the winding up in the morning becomes a habit, so that there is never any fear of its running down during a study. They are shown by a practical demonstration how a watch loses 0·05 of a second on every recording below 15 seconds and above 45 seconds. They are shown that it loses 0·1 of a second on every recording over 15 seconds but under 40 seconds.

(3) For the practice they are first given a simple and short study to do. A "master" keeps the overall time and the difference between the two readings is the trainee's error. This is reduced to a percentage against the "master" and the result recorded. It is worth recording here that it takes at least three weeks to learn to handle a watch. During this and the following practices the students also do the element write-up, which helps to keep them efficient.

(4) This is another lecture on the elements of motion economy. Again practical demonstrations are given, but this time the elements are deliberately misapplied in order that the trainees may be enabled to detect the faulty and wasted motions

(5) This is another practice involving the use of the stop watch, together with the writing up of the elements. This particular practice is made slightly more difficult by the intrusion of a factor, i.e. the operation is so rapid that the stop-watch readings have to include more than one element. This ensures development of the trainee's concentration.

(6) The error from the previous exercise is now graphed, and it is at this stage that there is a departure from the original conception of the percentage error, since, from the time of the "master" watch being set to the time that the student actually commences to record, quite obviously there has been a lapse of time. This and any other times, such as the operator leaving the job for any reason and the trainee returning from the study base to the training department, are called "buffers." It is obvious that a percentage of error cannot take place in the recording of a "buffer"; therefore, all the "buffers" are now totalled and are added to the overall time and then the percentage is worked out as before, but it will be readily seen that the percentage of error is going to be necessarily greater.

(7) The next exercise is similar to the one just described.

(8) The résumé is given by the lecturer and covers all the foregoing points.

(*e*) Fifth Week

(1) The fifth week starts with a report write-up, and it is at this moment that the trainees are shown a copy of the personal report of their progress, which has been made to the Management, and if the need arises for telling trainees that they have not so far matched up to standard, then this is done.

(2) The whole of this week with two exceptions is spent practising and graphing the error as before indicated.

(3) One of the exceptions is a talk by a member of the management on the functions of management. Generally speaking, the assistant works manager is the one best fitted for this task. His talk will be based on the need for accurate time study observations in order that the incentive system may yield the highest percentage of results. The management representative will lightly touch upon industrial relations, i.e. relations between the time study observer and—

(*a*) The superintendent.
(*b*) Supervision generally.
(*c*) The charge-hand.
(*d*) The operator.

The management representative will naturally concentrate upon the need for smooth and efficient running of the time study department, and will demonstrate the use of time study as a measurement of productive efficiency.

(4) The résumé is given by the lecturer and covers all the foregoing points.

(*f*) Sixth Week

(1) The sixth week commences with report writing, and again it is suggested that the lecturer leaves the students alone to develop their own style.

(2) Elements of speed and effort. This is a long talk and discussion and should take at least the whole of one morning. The lecturer will describe how the speed and effort factor measures speed of the operation in relation to the amount of effort required efficiently to perform any given function. The lecturer will dwell upon the importance of the fatigue ratios and the need for observation in connexion with the reduction of unnecessary movements and the elimination of waste effort. Practical demonstrations will be given,

i.e. the lecturer will perform the function of picking up a screw, locating it, and driving it home with a "Yankee," and will perform this at various speeds in order that the trainees will be better fitted to gauge the various speeds. At this juncture, of course, any fine discrimination between speed/speed will be impossible.

(3) This is followed by an actual stop-watch check on the varying speeds, which also can be used as a stop-watch practice for the purpose of recording the percentage of error.

(4) In order to avoid monotony a talk should be interposed and it is suggested that the talk should be given by a member of the personnel department, or other suitable person, on the human factor in industry. This will deal so far as possible with the operator's reaction to being rated, and will point out the difference between, psychologically, earnings actual and earnings potential. The purpose of this talk is to enlarge upon the operator's temperament or reaction under study

(5) The speed demonstration is an interesting experiment. A long level surface is chosen, preferably (in the summer) in the grounds, where there will be no audience. A second alternative is in the canteen between serving hours. This level surface is accurately measured to 50 ft. (Experience has shown that 100 to 150 ft. is more desirable.) Adopting Barnes' theory of normal rate being an average person walking at an average speed of 2·8 miles per hour, including relaxation, it will be seen that it is fairly easy to assess and reconcile flat walking pace over a distance of 50 ft. as being 12 seconds. The experiment consists, first of all, of each trainee endeavouring to walk at flat rate, and this is clocked off by means of the stop watches; following this each trainee walks the distance at least half a dozen times at varying speeds. One trainee is given the stop watch to clock each actual time, which is not revealed until the end of the experiment.

(6) Each trainee thus records his impression of the speed and effort factor involved; for example, anything between 60 (flat) and 120 (double time). This experiment clearly portrays the difficulty of maintaining double time even for a short period; it also develops the trainee's estimation of speed. The results of this are graphed (Fig. 23), and the percentage of error is arrived at by the following formula—

It is known that flat rate is 12 seconds at a 60; this, therefore, is a common denominator which, employed together, gives a total of 720. The actual time that the "victim" takes to walk the distance is divided into this total of 720. For example, if the "victim" walks

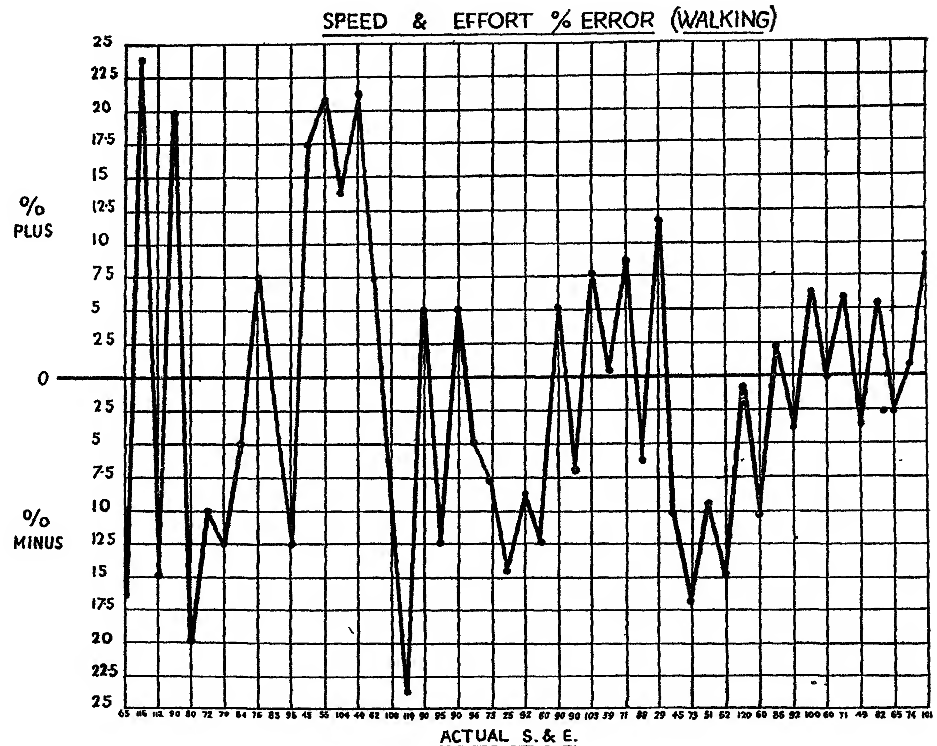


FIG 23

This graph clearly illustrates the wild guesses made by the trainee at the beginning, it also shows how by assiduous practice the percentage of error can be brought down to reasonable proportions

the distance in 8 seconds, 8 into 720 is 90, i.e. time and a half rate. The actual estimation by the trainee of the speed and effort may have been 100; we know the actual time taken is 8 seconds and, by reconciling the estimated speed and effort by the actual time taken

$$\left(\frac{8 \times 100}{60} \times 13{\cdot}3\right),$$

therefore the percentage of error is a "plus" figure (since it is more than flat) of 13·3 as to 12 × 100 13·3 − 12 = 1·3, and

$$\frac{1{\cdot}3}{12} \times 100 = 10{\cdot}8 \text{ per cent of error.}$$

This is the percentage of error recorded on the examples shown This is continued until a constant factor of 5 per cent can be shown on the graph.

(7) The résumé is given by the lecturer and covers all the foregoing points.

(g) SEVENTH WEEK

(1) The seventh week is commenced by the report write-up, which is treated in a manner similar to the former.

(2) The whole of this week is taken up with practising speed and effort and graphing the percentage of error. It will be noted that the title changes from "travel demonstrations" to "speed and effort practice." This is because after a fair average has been reached the trainees pass to studying actual operations.

(3) It is surprising how rapidly they fall into the method of assessing the actual speed and effort, and a very good check can easily be made on the results they achieve in studying actual jobs. As a matter of course the trainee will have obtained the operation name and part number together with the operator's name and number. This is obtained not only as a matter of practice, but primarily to check against the speed and effort reading efficiency of the trainee, which is accomplished as follows—

First, it must be clearly understood that there is no guarantee that the actual existing rate on the job is necessarily correct; methods may have altered or a faulty rate may have previously been applied. Therefore the trainee, after calculating his own rate according to his own estimation of the speed and effort factors involved, checks the actual bonus earnings of the operator with wages department by reconciling his own with that shown on the wages books and comparing both of these figures with the actual

bonus earned; it is then easy to assess the efficiency of the time study trainee (individual job, of course). .

(4) The résumé is given by the lecturer and covers all the foregoing points.

(*h*) Eighth Week

(1) The eighth week commences with the report write-up and this week mainly consists of practice as before mentioned.

(2) It will be seen that on three occasions it has been thought desirable to include a stop-watch check, that is to ensure that the efficiency of the stop-watch reading has remained constant.

(3) It will also be seen that there is a special section devoted to tabulation queries. It is advisable for the lecturer to obtain some actual tabulation queries and run through them in conjunction with the trainees, demonstrating how the wrong operation number or the wrong part number can mean that no rate is applicable, and showing by a practical demonstration how to overcome this difficulty.

(4) The résumé is given by the lecturer and covers all the foregoing points.

(*i*) Ninth Week

(1) It will be seen that the ninth week has its report write-up. As this is the second month of the scheme it is at this point that serious consideration is given to the desirability of continuing some trainees as regards whose continuance there has been some diffidence. It is unfair to management and to the trainees' class as a whole to continue with those people about whom diffidence has been felt regarding their suitability either of temperament or actual ability. If it is decided that certain of the trainees must be told of their unsuitability, then they should be given this information, quite obviously in private, and arrangements should be made for their transference to another department.

(2) It is desirable that a practice investigation should be held. This is performed best by building a "mock-up" in the training department and supplying all the relevant parts and allowing each trainee to decide for himself the best lay-out; then all the trainees with the exception of one, who acts as operator and performs the function of assembly, study the sequence of operation. At this stage each method is considered separately, and the optimum of speed and effort efficiency is the determining factor regarding the best method.

(3) There should be a practice speed and effort similar to that

previously arranged, and this can also include the stop-watch percentage of error.

(4) It is desirable that about this period the trainees should practise the art of reading clock cards. They should be given the information regarding the clocking on and off meal breaks, i.e. when these cards have been filled in they should be able to read accurately the checker's or inspector's figures on the cards and work out the actual bonus earned.

(5) Speed measurement. This is a question of experiment. It is advisable to have an easily discernible field of travel for one hand, and this time performing a function; it is suggested that the function is one of using a "Yankee" screwdriver. Then this element is broken down carefully into three—

(*a*) Reach out and pick up "Yankee."
(*b*) Travel to locate in head of screw.
(*c*) Drive screw home.

It then becomes fairly easy to observe the difference in speed demonstrated in picking up and the driving home function. This enables the trainee to attune his mind to the different factors governing speed, effort, and speed/effort.

(6) The résumé is given by the lecturer and covers all the foregoing points.

(*j*) Tenth Week

(1) The tenth week commences with the usual report writing, which by now should have reached a very high standard.

(2) This is followed by a talk on a special subject, e.g. die-casting. It is suggested that one of the experts on this subject should be procured in order that the very best of the available talents may be used.

(3) Then comes practice on both speed and effort and the stop watch until each in turn has reached a constant standard of accuracy.

(4) This is followed by another talk on a special subject, e.g. Bakelite moulding. It is at this talk that special emphasis on the importance of ensuring very correct cure time is made. If the rate is inclined to be lax, the cure time is extended unnecessarily and, if the rate is inclined to be tight, the cure time will suffer with, of course, a correspondingly higher increase in rejects.

(5) Stop-watch practice can be interposed between the preceding talk and the one which follows.

(6) The talk on cutting tools should be given by a cutting tool expert, and the purpose of this talk is to emphasize the great need

to ensure that the observer is quite satisfied that the correct set up has been made. In view of the relative merits and demerits of tip tools, emphasis can be laid here on the need for recording the tip tool in the study.

(7) The previously mentioned stop-watch exercise will be graphed and this in turn will be followed by a résumé of the week's activities.

(*k*) ELEVENTH WEEK

(1) The eleventh week's activities are prefaced by a report write-up and, in the main, this week is devoted to practising speed and effort and stop watch.

(2) It will be seen in this week that reference has been made to "check studies." It is quite a good idea at this stage to use the trainees by allowing them to check studies which are in dispute; even if their results are negligible, nevertheless the thought that they are apparently contributing something has a strong psychological value.

(3) During this visit it will be seen that more time is given to motion economy, with which the trainees should be allowed to experiment in the shops.

(*l*) TWELFTH WEEK

The twelfth week is commenced with a report write-up, and this week follows much the same course as the one immediately past.

(*m*) THIRTEENTH WEEK

(1) This, the last week of the course, has its report writing

(2) It is a memory refresher in the form of visits to the methods department and the progress planning department. There are practice, speed and effort, studies, stop watch, percentage of error to record, and then the whole of the last day is spent in a complete résumé of the course.

ANALYSIS

Having decided in favour of a candidate, the first step is to equip him with the necessary knowledge.

It will well repay any company to look upon the first three months of service as a loss rather than to ill-equip the candidate and thus have exaggerated bonus earnings and labour troubles, apart from the ill repute that rebounds upon the department. For this reason three months is taken as a minimum training period, which is made as comprehensive as possible.

Introductory Interview (1st Day)

The candidate having been judged on an agreed standard based on previously mentioned classification, the purpose of this interview is to inculcate the responsibilities devolving upon the time study engineer. The syllabus should be explained and emphasis laid upon the personal factors involved. If the candidate lacks a knowledge of industrial economics or administration, he should be encouraged to enrol at a local technical institute. (The same would apply for mathematics, etc.)

At this interview the candidate will be told the necessity for balanced judgment and the high degree of skill, and of promotion prospects, etc., special emphasis being laid on the need for the development of an *esprit de corps*.

When this is completed the chief of the department can be contacted and for the rest of the day the candidate will be given samples of the forms used, together with a brochure of instruction (it is advisable to have a special trainee's folder prepared), which he can study (routes to canteen and usual offices, etc).

To Training Department if One Exists (2nd Day)

It will do a considerable amount of good for the candidate to start off here, seeing *what the operators of his proposed floor have to learn*. This, incidentally, will also be an introduction to motion economy. Some time during the day he will visit the works library, if one exists (if not, the local technical library), and be afforded facilities for the borrowing of such books as deal with his special subjects. This will also drive home the source of information for the future.

Tour of the Factory (4th, 5th, and 6th Days)

This is placed here so that the candidate may more easily recognize the manufacturing processes. To thrust a candidate into the works on the first day is to confuse him, since he is unable to correlate, in his mind, the varying processes. He will spend part of his time on each section, and one whole day on the section for which he has been scheduled.

Second Week

In his brochure and folder will be forms, graphs, instructions as to reconciliations, etc., and general information regarding time study methods. During the second week he will be given studies to write up and reconcile in order to familiarize himself with the

formulae and terms. All this week should be spent doing these tasks, so that *right from the start* he knows the methods adopted by the organization

THIRD WEEK

This week will be spent partly in the wages department, and partly in costs This is to familiarize him with the methods of tabulating and the working of the wages system. In costs he will be shown the reason for careful rate-fixing, the system of quoting, costing repairs, etc

FOURTH WEEK

So far the candidate has not touched a stop watch, but now he is fitted to learn the technique of making readings. He will be taught the principle of the "fly-back" stop watch, how to judge the travel between seconds, and how to synchronize.

He will now practise taking readings *only* on a repetition job, and will have his readings checked against an overall time. The results of the error ratio will be graphed by himself. The candidate should practise on this until the error ratio is down to 4 per cent of the overall time. Careful records should be maintained on the graph showing overall time and percentage of error, and type of observation. This will probably take three weeks at least.

SIXTH WEEK

When this stage has been satisfactorily reached, the candidate will then commence to record specific operations and break them down into elements. These too will be graphed in a manner similar to the former. The purpose of this training is to correlate eye and watch to *each element.*

N.B. The attention of the reader is drawn to the fact that the question of speed and effort efficiency has not been touched upon; although while the above time checks have been taking place, the impression of speed has been slowly forming in the candidate's mind, as yet he has not been taught to assess it, but by now his mind should be forming an "approach" as it were.

SEVENTH WEEK

This stage reached, the candidate should be allowed to accompany a time study man "on the rounds." He will see the studies being made and, while this is being done, he should take overall times himself. He should follow the job through and be encouraged

to make suggestions *re* motion economy. This should carry on for a week at least.

He should write up reports on every job on which he has accompanied the time study man, noting the improvements (if any) he himself has suggested. This will show him the importance of motion economy and give him valuable experience in writing reports.

EIGHTH AND NINTH WEEKS

He will now start to learn the elementals of speed and effort The candidate will proceed to the training department or other suitable premises and be shown the differing speeds on the same operation by—

(*a*) Learner
(*b*) Semi-skilled operator.
(*c*) Instructress or skilled operator.

Since speed values are the main concern, only the simplest operations at this stage need be taken. This should be constantly practised and charted until the operation has reached a uniformity of values.

When this has been successfully accomplished, the candidate can now be taken on the floor. By giving him a *proven* rate to study, his progress can be established. He should follow this through until he can state at a glance the speed at which any operator is working.

TENTH WEEK

He should now go back to his training desk for a revision in the two-day syllabus in order that he may be made more fully aware of the application of the bonus system. This completed, he should be introduced to the bonus query system and be allowed to handle some of these

The rest of the week can be devoted to checking rates in dispute and to making investigations.

ELEVENTH WEEK

He should now be able to travel to the planning and progress departments to learn the checking system. Three days should suffice to equip him with a knowledge of the checking difficulties likely to be encountered, and from here he should pass to the inspection department to obtain a grasp of inspection standards and a knowledge of tolerânces, and, in conjunction with this, reading of blue-prints to discover tolerances permitted and called for on drawings.

PROGRESS CHART TIME STUDY TRAINEE.

TRAINING DEPT	FACTORY TOUR	TIME STUDY DEPARTMENT	WAGES DEPARTMENT	COST DEPARTMENT	FLOORS	ELEMENT BREAKDOWN MOTION ECONOMY	SPEED & EFFORT RATING	TRAINING DEPT	PLANNING DEPARTMENT	INSPECTION DEPARTMENT	STUDY BATCH
SUBJECTS COVERED		INTRO. TO FORMS SYSTEM FILING ETC.	BONUS TABS ADJUSTMENT KARDEX QUERIES	QUERIES	STOP WATCH READINGS & OVERALL TIMES % OF ERROR GRAPH	ON FLOORS WITH TIME STUDY MAN	TRAINING DEPT & ON FLOORS	SUBJECTS REVISED		ON FLOORS	
COMMENTS											
SIGNATURE											
DATE											

FIG 24

The Progress Chart is operated by having the relevant details filled in by the instructor of the department which the trainee is at that period visiting. Under the section of "Comments," the instructor will indicate his opinion of the trainee so that an accurate picture can be built up which, based on different sources, will be free from bias

TWELFTH WEEK

This is the final test and should take the form of following one batch of material through from goods inwards right up to the final assembly stage and then to packing and dispatch, setting rates on all questions and reconciling these with existing rates.

CONCLUSION

This scheme has been made as comprehensive as possible so that a plan may be drawn up and adhered to. In the past the training of "domestic" trainees has usually been a haphazard affair resulting in widely differing interpretation of speed and effort and stop-watch accuracy. The disparity so caused has led to many anomalies in time study with a consequent loss of prestige to the department.

It is not to be assumed that even when the time study man has passed this course he will be *fully* trained, but at least his training will have been standardized and this standardization is something that is sorely needed.

The candidate should have a standardized progress chart which should be initialed as he passes through the various stages, thus making it possible to see at a glance the extent of his progress and date of passing; when filed, this will provide valuable data for future reference.

SUGGESTED EQUIPMENT FOR THE TRAINEE

A progress form (see Fig, 24) is an essential part of his equipment In addition—

1. A personal folder should be provided. This will take the form of a block note pad, upon which he can record his notes for subsequent transference to the report forms. In the folder should be copies of the various forms used by the time study observer together with his graphs and charts.

2. The trainee should be equipped with tables (see example). This provision will lessen the time taken to work out the various formulae.

3. Necessarily the trainee will have a watch. This should be equipped with a safety-thong right from the outset, except where a mechanical holder is provided

4. A slide rule should be provided or, if the provision of this is contrary to the policy of the firm, then the trainee should be encouraged to acquire one

5. Wherever the training is to be held, personal lockers should be provided There is valuable training in inculcating the habit of tidiness. An untidy desk is no help to efficiency.

6. Textbooks should be provided on loan The trainee should be encouraged to read up all he can about the subject at home.

CHAPTER IX

THE CINE-CAMERA IN STUDY WORK

THE uses of a cine-camera in industry are many. It can be used for (1) the training of time study personnel; (2) as a rating measure for the purpose of ensuring a standardization of rating efficiency; (3) to "prove" rates by means of checking against the time actually taken; and (4) in motion study

Cine-cameras, in themselves, are relatively cheap; the processing and editing represent an expense, however, that must be carefully weighed against the relative savings that will accrue from its introduction. Clearly, it would be uneconomic to make a film if the production run is to be a short one, unless there was an extra-special need.

In these days of high-precision work, the cameras produced are usually of high efficiency, and this, coupled with simplicity of handling, makes the operating of them a simple matter. Highly-trained photographic staff, therefore, need not be taken into consideration of the economics of the job Most cameras have a wide range of aperture, with the result that it is comparatively easy to choose one to suit factory lighting conditions. Sometimes, however—in the press shop, for example—it will be necessary to supplement the normal lighting with flood lights. Where possible, this should be avoided, for it creates a different set of conditions for the operator and for time study work upsets the rating efficiency.

EQUIPMENT REQUIRED

Camera. This should be of a reputable make A 16-mm. is probably the best size and the operating gear should be motor-driven. The speed used will be best decided by experience, but a useful speed is that of 16 frames per second.

In order to aid the lighting problem, a fast film should be used. The aperture will have to be decided upon by means of an exposure meter. There is usually a wide range of aperture and lenses, but nothing more than f.59 or less than f.8 will be likely to be needed.

Projector. It is best to have a separate projector, otherwise the camera will be too heavy to handle comfortably—thus reducing mobility. The projector should be capable of varying speeds and should have both manual and power mechanism—the power for high-speed demonstration, and the manual for selection and analysis.

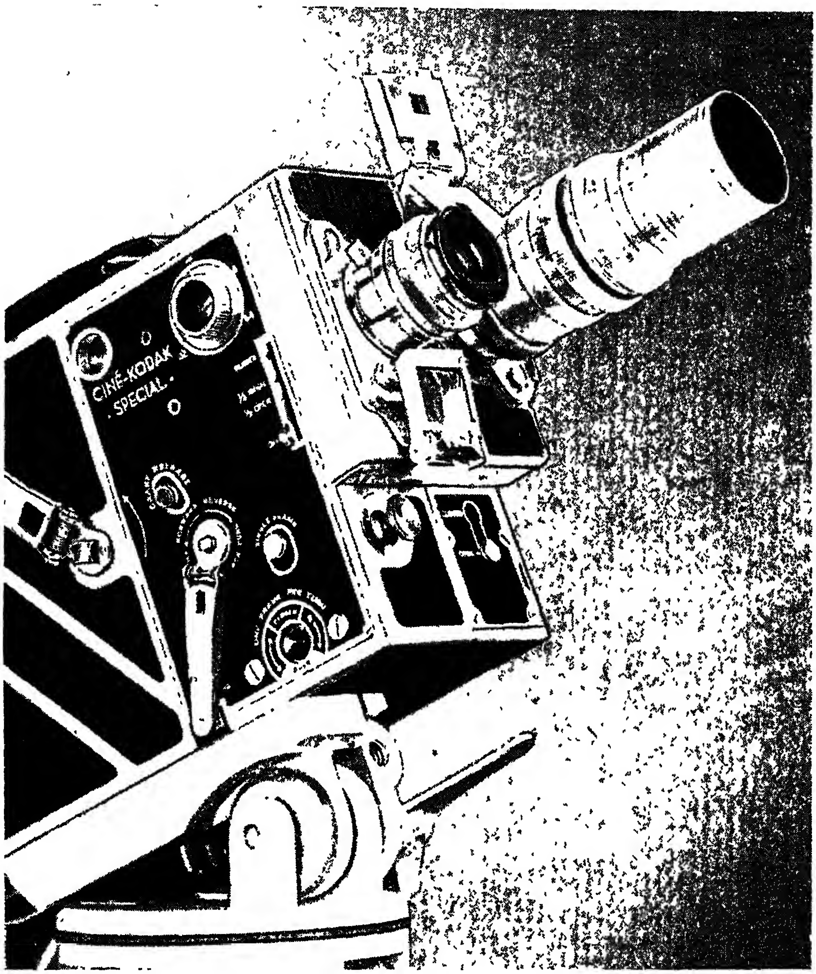


FIG 25
This is a fine example of a camera for the taking of shots in the shops. It is an expensive type, but has a wide range of aperture covering nearly every type of lighting.
(Photo by Kodak Limited)

Light. Supplementary lighting is desirable and can be best applied by means of a set of "floods." There are many brands on the market, the selection of which will depend upon the degree of flexibility required.

Study Room. A study room, which can be adapted to a darkroom, is necessary. It should be fairly large in order to accommodate an audience for training and demonstrational work.

THE CAMERA AND ITS APPLICATION IN INDUSTRY

Time Study. The cine-camera will be a worth-while addition to the time study department, for by its use rates are enabled to be checked and proven.

Its greatest value, however, is keeping a conception of speed constant in the experienced time study observers' minds. Accurate checks can be made on the efficiency of the rating in the department, thus assuring a consistency of rating throughout the organization. Frequent checks are made by varying the speed of the projection, and getting the time study observers to rate accordingly. For instance, it will be known at what speed the picture was taken, e.g. 960 frames per minute, and if the projection is at the rate of 1425 frames per minute, the observers should be rating at 80, so—

Taking speed to be TT.
Let projecting speed be TP.
Let rating speed be PS.
Let reconciliation speed be R

$$\therefore \frac{TT \times RS}{TP} = R$$

Thus
$$\frac{960 \times 80}{1425} = 54{\cdot}0$$

This final figure is the speed at which the operator *was* working at the time the study was taken. To finalize this, perhaps it would be desirable to check this rating by a majority reading at the time of the projection and ally this to the rating of the watch study, taken immediately prior to the photographic study.

Time study can also use the film for the purpose of establishing a change in method. As previously explained, it is important that the most meticulous attention is given to the establishment of the sequence of motions and the method adopted in production work. This method of recording the sequence and method is unchallengeable.

Motion Study. It is in this connexion that the cine-film really comes into its own. Although a great deal can be done to eliminate

errors in production and method on the floor, nevertheless a film taken of the job being done lends itself to a more close attention to detail, the results of which far transcend any of those taken by the normal analysis.

The observer takes the film and, when it has been developed, goes through each stage with meticulous attention. He can determine the degree of handling time, the efficiency of motions, the lay-out of the bench, the utilization of hands, and the amount of digital idle time

All this can be done much more effectively in the study room than in the shop. Further, it provides useful information, which can always be kept on record, of the changes that have been made. By the use of the clock, full micromotion can be used and analysed There is an excellent method of recording this and, by using the analysis shown on page 122, the study can be built up accurately, thus making it possible to analyse more efficiently.

Whilst projecting for analysis, it is advisable to use the hand crank in preference to the motor, since this permits the observer to take his time in recording the varying elements, and to discover flaws.

The observer must abstain from trying to correct motions before the analysis is complete. It is not until the actual study has been written up that the full value of the film projection becomes apparent. Even a simple operation of "seek, locate, grasp, bring to hand, and locate to jig" has been known to reveal many flaws by means of the study, which, had the observer been content to remedy while the film was being run through, would have resulted in a large number of superfluous operations being completely missed.

When the observer is satisfied that all the flaws have been noted and the instructions issued for rectification, it is desirable to have the operator in to demonstrate the proposed change to him; this aids in achieving operator co-operation, which will be of inestimable value.

Then, again, it is often the case that the operator will have ideas of his own; even if these ideas are of little value, the psychological effect of their being considered will more than repay the time spent in discussing the idea.

TRAINING OPERATORS

The training value of films cannot be overrated. First, there is the point that films provide a ready way of familiarizing the operators with the firm's products. Then there is the question of

the safety factor; by skilful editing, "awful warnings" can be dramatized.

If it is desired to train operators in a particular function, the film can be "looped," i.e. a loop of film covering the particular process is cut from the main film (or a copy made), and is run through the sequence of operations it is desired to impress upon operators. It is in this connexion that the value of the "before and after" shots of the same operation can be used to demonstrate to operators the basis of motion economy.

The film can also be used for showing the high spots in inspection technique. Flaws can be focused upon by the camera, thus making it clear to the learners what is required of them.

Even machining can be taught by means of the cine-camera. The action of cutting tools, and the throwing aside of swarf (the different angle of the tools giving rise to different chains of swarf, thus indicating the correctitude of the tool, or otherwise).

Shooting. Depending entirely upon the purposes for which the film is required, there are slight differences in technique for the actual shooting. If the film is for time study purposes, then the conditions have to be as near natural as possible It is obvious that the conditions can never be exactly the same, because the fact that there is an observer, together with a camera, concentrated on the operation as well as the operator, must create a disturbing element It would be an extreme case of phlegmatic indifference which could cause an operator to ignore entirely this outside influence.

Unless it is absolutely necessary, it is advisable to avoid the use of additional lighting; although this addition would make a better picture, it would introduce abnormal conditions into the work.

A wide-aperture lens will help to overcome the lack of light, but will show its effect on the projection—the film will tend to be "smuggy," and the clear-cut definition will not be present. However, it will serve the purpose for which the film is taken. For checking time studies, the film should be shot at 960 frames per minute. But, whatever the speed that is being used, a record should be kept so that the reconciliation of the speed assessment can be more accurately portrayed.

It will not be necessary to film all the phases of the job; it is a waste of specialized skill and material to film the replacing of bins and the trueing up of tools, that is, unless there is a special reason for wishing to record these factors

For the film only about a dozen cycles need be shot; the camera takes care of all the elements that *may* be missed by the human

observer, which makes it necessary for him to study a greater number of cycles.

When the film has been developed, a close study can be made of the result, and the rate can then be cross-checked against that issued on the floor. Disparities, if any, will be thrown up by this method, and if they are sufficient to upset the rate by, say, 5 per cent, then the operator should have the benefit of the greater amount.

Motion Study. If the purpose of the film is for motion-study analysis, then the conditions surrounding the job *can* be altered by the inclusion of lighting adjuncts. The film should be speeded up in order to avoid the small motions performed by the fingers being missed. If the film is taken at a fairly low speed, some operations become disjointed, the "camera eye" will not be fast enough to catch the smaller elements, e.g. it will be seen that the hand reaches out to grasp a machine handle, but the actual amount of contact will be missed because it is so small an element. So the faster the camera, the greater the amount of detail. After all, the minute detail interests the observer much more than the obvious Therefore, a taking speed of 24 frames per second is desirable (approximately 1400 frames per minute).

Because the shooting will be done from the point of view of analysing motions, the cine-operator will have to concentrate on the motions spread over a wide field, unlike those taken under time study conditions, where only the productive motions are recorded All the "foreign elements" must be included in the motion-study film, in order that these may be suitably analysed in themselves For example, if the operation being filmed is a simple capstan job involving "knurl, recess, and part-off," the cine-operator will have to include in his sequence of shots the stock-bar control handling, and the adjustment for the cross-index. He will also record the turning off or on of the lubricant, together with the elements which go to "placing aside," but he will have to go even further than this —he will have to record the loading of the stock bar, the taking away of the finished supply of parts, the gauging, if required, the placing aside of the gauge, the pick-up point for the file (if a file is used), and the placing aside of the rejected parts, etc. In other words, the cine-operator will concentrate in getting a complete picture of all the elements which go to make up the operation; if he does not do this, if he contents himself with selecting the operations which directly concern production on the lathe, and does not take into account all the ancillary functions, he will then be motion-studying only the elements which are concerned with producing

and not those which are concerned with "getting ready" to produce, and "clearing up." It is on these elements beyond the immediate cycle of production where the motion economist can produce many changes.

OPERATOR TRAINING

When the film is being shot for the purpose of training operators, then artificial lighting will be required, carefully placed, and the operator concerned will need to be rehearsed. In this case, it will be seen that the film is to serve an entirely different function from the two noted above, because, owing to the training factor being involved, the film is concerned only with the imparting of knowledge, and will not deal with such subjects as checking rating efficiency or motion analysis. It is for this reason that the operator concerned must be carefully schooled in the part he has to play in the making of the film. At this stage, it is not necessary to worry about the captions or descriptions or (if a sound track is to be used) the commentary. The film should be shot at a fairly even speed, about 16 frames per second, and those portions of the operation which it is desired to impress upon the audience should be taken at a faster rate, say 24 frames per second. This is for precisely the same reason as is described in the previous section, i.e. to make quite sure of including all the motions concerned in performing the operation.

In making this film, special care and attention should be given to the correct sequence of operations and, probably, what is of as great importance, the correct manipulation, i.e the efficient utilization of motion economy. In fact, it would not be a waste of time to preface the film with a short talk on the benefits of motion economy and draw attention to examples of this in the film itself.

Special techniques should be "looped," i.e. a cut from the film is made containing the special technique that it is desired to impress upon the audience, and it is joined together and run through the projector in the form of a continuous band, thus repeating the performance several times. By this means, of course, attention can be centred on any particular function it is desired to demonstrate. This can be utilized to the full in many ways, but its particular value is shown in the fact that all operators learning the particular technique will learn it in the same way. This is important. The film, therefore, has a peculiar merit that cannot be quite equalled by any other means, that is of showing operators how to perform the job exactly. No personal idiosyncrasies can possibly creep into the tuition.

TRAINING OF TIME STUDY OBSERVERS

The training of time study observers by means of films has a similar merit to that expressed in the previous section, inasmuch that the standard of training will be constant, and, therefore, cannot vary. In this case, an operator is selected and carefully schooled in what is required of him, and then the film is shot. The film should be run at a constant speed, i.e 16 frames per second, but the operator should be told to increase or decrease speed according to the instructions given her during the course of the job. Thus, by varying the operation speed, it is possible to demonstrate to a class the relative speeds which they can expect, and to train their eye in the recognition of speed alterations The carefully selected job should be photographed and, during the course of the photographing, an operator who has been specially trained should work progressively from 60 flat up to 90 (time-and-a-half rate). Thus, it is possible to ensure that the time study observers who are taking the course of training are fully aware and appreciative of the difference in speed. Again, advantage should be taken of the "looped" form of presentation, thus enabling the same operation to be run through repeatedly, and this can be used for practice studies.

It has been found by experience that observers under these conditions have a tendency to rate slightly higher than under normal conditions in the shop, and, in this connexion, anything up to 5 per cent can be expected. However, once in the shops, they soon lose this tendency to over-rate.

CHAPTER X

ELIMINATION OF WASTE

It is a safe assumption that there is no factory or business organization, however efficiently run, that does not have waste. Of all the detractions from efficient and therefore maximum production, waste makes the greatest contribution.

Waste is the most insidious of all the brakes on production It is not always readily discernible, and yet, where it is apparent, it nevertheless escapes attention merely because habit is so strong and the perpetrators of waste are so close that they cannot see the wood for the trees.

Where does waste occur? A moment's reflection will show that it occurs nearly everywhere in industry. Nobody is immune from the results of waste, whether expressed as TIME, EFFORT, FUEL, MATERIAL, EFFICIENCY, or SKILL.

METHODS AND MOTION STUDY

Motion study, the science of observing, will do much to spotlight the waste Motion study, however, will be valueless unless there is machinery for implementing the remedies.

Thus it is necessary to provide the motion study observer with a means of getting the alterations carried out, and, let it be added, carried out promptly. To have a motion study observer breaking down and analysing the various causes of waste and yet not to give him the necessary authority to make alterations is, in itself, waste personified!

The motion study observer should be able to determine the respective merits of alternative methods, he will be on the look-out for improvement in technique; and he will be specially qualified in the determination of effective effort and productive skill. His training should enable him to suggest jigs and fixtures; his background should provide experience which will guide him in the use of machinery, and, above all, his observation should be so developed that he will be able to locate waste without loss of time

The science of motion study implies the practice of motion economy. This is very true, it can be seen, however, that the observer will also be skilled in many other branches than the determination of waste motions

The motion economist holds an important position and, at the least, his status should be managerial.

The practice of motion economy, reducing it to simple language, and cutting through the fog of technicalities that surrounds it to the exclusion of its real import, is no more than the aim totally to eliminate waste. In whatever form this appears, the motion economist will be responsible for—

(*a*) Locating it.
(*b*) Studying and analysing it
(*c*) Isolating the cause
(*d*) Removing the cause

Since waste occurs everywhere, to a greater or less degree, an analysis of the principal fields where it is rampant will doubtless prove useful

Obviously, the production lines provide a fertile field for wasted effort, but the ancillary departments also provide their quota of profit-losing waste.

It is evident in—

A Machine Shop

1. Waste effort through bad tooling
2 Poor lighting
3. Bad machine positioning, causing congestion
4. Poor jigging, involving physical strain.
5 Low service efficiency Operator does own feeding
6. Wrong speeds, either too slow or too fast.
7 Too much handling, i e picking up and putting down
8. The use of hand tools instead of power.
9. Bad position of lock keys, necessitating "search "
10 Non-anchoring of gauges, e.g. vibration causing falls and breaks
11. Bad set-up, leading to rejects.
12 Poor tooling service, machine waits while tool is being re-ground
13 Starter button out of normal reach.
14. Fly presses not properly balanced
15 Inclined presses being used as verticals
16. Operating handles of drill-presses not extended
17. No chutes or slides for feeding or removal of parts
18 Racking for machines (capstans, autos, etc)

B. Sub-assembly Lines

1. Poor bench lay-out, necessitating "search."
2 Lighting
3. Hand tools instead of power
4. No fixtures. One hand used as vice
5. Small parts located in boxes, necessitating picking up.
6. Selective assembly caused by poor pre-inspection
7. Bad seating, causing strain
8. Ill-balanced operator lines, causing delays
9. Poor feeding. Operators having to obtain own supplies.

10. Physical transport, instead of gravity chutes or conveyor belts.
11. Extended inspection, resulting in a number of operators' work being scrapped instead of only one or two.
12. Limitation of individual speed due to large groups
13. Poor progressing, involving material delays.

C. Service

(a) *Inspection*

1. Test gear not located near line.
2. Measuring instruments instead of gauges.
3. Gauges not "anchored," necessitating "search."
4. Flow ill-balanced, resulting in "floats."
5. Too much handling due to bad planning of benches.
6. Not enough line inspection to check faults.
7. Insufficient standards Too much reliance on individual conception.
8. No immediate segregation of faults, causing repeated inspection
9. Immobile inspectorate, causing over-handling of parts.

(b) *Transport*

1. Congested gangways, causing hold-ups.
2. Manually propelled trucks instead of mechanical
3. Transport "empty."
4. No pick-up points, leading to line interruption
5. No pooling, causing empty lift journeys
6. No time-table, thus causing rushes in "priorities"
7. Manual supply instead of conveyors.
8. Wrongly designed bins, limiting stacking efficiency.

(c) *Storage*

1. Bins instead of tote pans on racks.
2. Portable ladder instead of rolling platform.
3. Manual transport instead of grid rollers
4. Serving hatch at end of stores instead of at centre.
5. Rapidly consumable parts stored away from hatch
6. Card index records instead of wall chart.
7. Serving hatch instead of "stable door" for heavy parts
8. "Take" and "Give" using same hatch.
9. Counting parts instead of weighing.

(d) *Cleaning*

1. Degreasing manual lifts instead of gantry hoists
2. Fettling: hand instead of flexible tools
3. Deburring: hand instead of "offering to drill"
4. Gate breaking: hammer instead of arbor tool.
5. Flash removal. hand file instead of rotary file.
6. Sweeping: during work hours instead of during work breaks.
7. Swarf removal: hand brush instead of blow gun.
8. Baling: hand baling instead of compressor.
9. Scrap sorting instead of pre-segregation.

D. Final Assembly Lines

1. Portable tool tables not supplied.
2. Manual tools used instead of power
3. Blue-prints issued to semi-skilled operators instead of "mock-ups."
4. No supply sub-stores, for quick delivery.
5 Headlamps not supplied for dark corners (on large assembly)
6. Angles not foreseen, therefore angle drivers not supplied.
7. Tool belts not issued for interior assembly.
8 Thread-cutting screws not used enough
9. Full use not made of cored solder.

E. Feeder Shops

(a) *Die-casting*

1. Ingots trucked instead of overhead conveyor.
2. Heat fatigue not countered.
3. Die removal tools ill-designed, creating strain
4. Gate breaking done whilst hot.
5 Chute slide not fitted to save lift.

(b) *Bakelite Moulding*

1 No chute slides to save lift.
2. Individual cure time clocks not supplied
3. Inserts tapped out with hammer and tool instead of pressed out
4. Powder not pre-measured or compressed as tablets.
5. Moulds not duplicated, so that service time is increased and cure time idle
6 No "spin off" tool for threaded mouldings.
7. Fettling not done during cure time.

F. Paper Work

1. Insertion of carbons instead of carbon-backed paper
2. Writing up description instead of using codes.
3. Issuing individual control instead of duplicating off master.
4. No provision of greaseproof envelopes for machine shop paper work
5. Non-standardization of forms.
6. No periodic checks of paper work to see if now redundant

G. Clerical (Factory)

1. Division of authority, leading to confusion and overlapping.
2. No "central mailing," leading to several people delivering own paper work
3. Personnel not "walled off," thus suffering from factory noises.
4 No tables issued, all calculations being worked out.

The above list of faults is only meant to offer a guide to general principles. In all the operations quoted, individual attention to detail will throw up other improvements.

It will be seen that the listed causes of waste follow well-defined

outlines. All the faults shown should be immediately observable. The operator's wasted motions cause an even greater concern and this is discussed later.

To break down the survey listed on page 127.

A. Machine Shop

1. TOOLING. The tooling and its correctitude is a matter more for the tool design department, but nevertheless it is desirable that this should be carefully examined. If the swarf is being thrown on the work, then the tool design can probably be improved. The swarf will have to be brushed off, usually by hand, and this involves wasted effort The amount of material to be removed by each tool demands its own investigation and the observer should satisfy himself that the tool is doing all that is asked of it.

2. LIGHTING. Apart from involving eye strain, headaches, and slowing down the work, poor lighting also involves hazards. If the lighting is so poor that the operator has to peer, this brings the head too near the shafts for safety, particularly if the operator is a woman. It is a good idea to have the working areas of the machine painted in a contrasting colour. A pastel shade is best from the point of view of good reflection. (See also page 181.)

3. BAD MACHINE POSITIONING. To place turret lathes adjacent to service gangways may be good lay-out from the angle of incorporating the bar loading, but it is bad from the point of view of accessibility of truckers, operators, and feeders. Care should be paid to this point, and while it is sometimes impossible to get changes made in regard to machine positions, nevertheless there should be some sort of arrangement made whereby the observer sees new plans before they go to the plant department

4 POOR JIGGING. Poor jigging, involving physical strain, is a cause of operator inefficiency. It often happens that when the jig and tool design get down to the job, they are not familiar with operator characteristics of motion, with the result that jigging-up is often called for, involving the use of thumbscrews (butterfly screws). Needless to say, this is a prolific cause both of wasted effort and lost time. Cam-operated jaws are often a satisfactory solution. Air-operated chucks and fixtures are another alternative. Wedge clamps provide yet another solution. Consider, when a thumbscrew is used it usually requires four turns to lock, one locking turn and four turns to unlock. At 80 pieces per hour for a ten-hour day, this involves no less than 7200 turns that could be entirely eliminated.

5. Poor Service In press shops it is customary (or should be) for labourers to load machines and to bring up supplies. On blanking machines labourers should be used to supply materials and remove blanks, trucking away the scrap as soon as possible. It often happens that the labourer is engaged elsewhere through no accurate division of work and responsibility being divided. When this happens, not only does the operator have to be involved in energy-wasting labouring, but the machines are idle for that amount of time taken up; this reduces the machine efficiency. Service labour should be apportioned to a battery of machines instead of being at everyone's beck and call Rather have the labourer idle for fifteen minutes every hour than the operator *and* his machine.

6. Wrong Speeds. These slow down the job if they are set too low, and cause rejects due to tool wear if set too high The operational lay-out card should clearly indicate the feeds and speeds, and operators should be warned against tampering with them It should be unnecessary for the operator to adjust speeds, that is, if the setter knows his job. Where speeds suddenly increase it is usually traceable to the time allowed, if the time is tight, operators will often increase the cutting feed or, if the time is right, operators sometimes increase speed in order to earn more bonus Supervision should be on the look-out for these subterfuges. If the time is tight, the time study department can be approached; if the time is right, then tool wear is an unnecessary burden and supervision must take appropriate action.

7. Handling Time. This is a most prolific cause of waste motion, detracting as it does both from operator and machine efficiency. Handling can be a serious drawback, and the observer should pay particular attention to this point It can often be overcome by raising the supply benches to a reasonable and accessible level For bench drills, a sloping bin is desirable in order to ease off the strain of selecting the part. For medium-weight machining, there should be a slide built on the left of the machine so that the casting can be moved up to the face plate without undue lifting Some shops have knee-high supply bins for machining This is wrong It means that the operator has to stoop to pick up the part. Assuming that an operator has to work under such conditions, on 70 pieces per hour for a ten-hour day, there is no less than 700 stoopings to pick up the part; truly a waste of effort that is neither productive of nor conducive to efficiency. "Putting aside" the part also represents a fruitful field for investigation. Very often the putting aside can be done by means of a gravity chute leading from the chuck to a bin

or perforated tray (to allow the lubricant to escape) on the floor beneath the machine. Of course, this would only be possible for small parts, say up to $\frac{1}{2}$ in. diameter. For medium-weight castings (rough machine), a zinc-lined slide similar to that described for loading can be used. It can lead down to a small loading bay from which it can be trucked. Where the machining is a follow-on operation, i.e. not from bar feed, the supply should be from above, gravity fed to a stop, so that the operator never has to worry about picking up or selecting, there always being one to hand. (See also page 177.)

8. HAND TOOLS INSTEAD OF POWER-OPERATED. This refers more particularly to the use of hand brushes in swarf removal, whereas if there is a compressor plant, there is no reason why a blow gun should not be used. Small air-driven rotary files can be used for "cleaning up" Air can be used more efficiently for the stock bar instead of using weights, since then there is no doubt about the bar coming right up against the stop.

9. LOCKING KEYS ON LATHES, CHUCK KEYS ON DRILLS AND TAPS. Both these cases call for "anchoring." Where there is a crowded machine table or bench, it is almost inevitable that the tools will become lost, thus causing a considerable delay due to "search." Where files are used for deburring on the machine, these too should be anchored in some way. An easy manner in which this can be accomplished is to rack them. A few spring clips, screwed to a board, is a ready suggestion And the choice of the position should come into the question. It is no use anchoring them out of reach, or on the wrong side to the hand that will use them most!

10. THE EASY LOCATION OF GAUGES. This is a matter that demands attention. The usual site for these is on the machine table or down in the trough, where, covered with oil, they become hidden under the accumulation of swarf. There is too a grave risk of damage from falling to the floor, due to machine-vibration. Even if they remain undamaged, a gap gauge especially will risk having the gap shocked.

Gauges should be boxed, in an easily accessible position, and in such a place that the hand can select and grasp without having to grope.

11. BAD SETTING. This does not properly lie within the scope of the motion study observer. However, he should know sufficient about the job to be able to detect flaws in setting. This is particularly applicable to mills, where the correct setting gives the best cutting speed. On capstans, the observer should be able to recognize when and where roller boxes, etc., are called for. These maintain

the finish and react upon the operator, less concentration of effort being required.

12. POOR TOOLING SERVICE. A prolific cause of time loss and consequent operator inefficiency are the delays associated with tool sharpening, trueing, and changing. The observer should insist, where possible, on duplicate tools being available in order to cut out the delays associated with tooling. Tooling service is an integral part in the build-up of efficiency in the shop. The more efficient the service that can be provided, the better the standard of machine loading and control.

13. STARTER BUTTONS. It is surprising the number of times the observer will discover that the stop/start push button is situated out of reach, due mainly to the ease of installation but without consideration for operator comfort—out of reach, that is, from the normal operating of the machine. Apart from the fact that this is wasteful in energy through having to reach, the risk of a tool breaking or damaging a part has to be reckoned with; in addition, the safety factor is one to be borne in mind. The button should be well placed, in such a position that the operator does not have to leave the working area. While on this subject, the observer should look out for "throw switches," and get them changed as soon as possible. Not only are these out of date, they are definitely hazardous, through the risk of accidental starting and stopping. Some sort of guard can also be introduced to prevent the "On" button being pressed while the machine is being set.

14. FLY PRESSES. These can be very exhausting to use. This is usually due to the bad setting of the stop, the handle coming too far forward to give an easy operation. The fly press is designed to eliminate the use of strength and, if an operator is pulling the handle round with both hands and so making hard work of the job, then the press has not been properly balanced. The work on a fly press should be easy; not so set that the operator has to use physical energy in order to form the part or press out the blank, or whatever the job happens to be. Incidentally, the loading of the jig in this operation calls for observation. The operator should be able to load only, and in the case of forming, the tool should have a spring ejector (or air ejector); in the case of blanking, or pressing out, the parts should fall through the base into a bin.

Where the press is used for broaching, the broach tool should be "trapped"; where the broach falls through on the floor, not only is this likely to damage the tool, it is also wasteful of energy and time due to the "recovery" factor involving both "stoop" and "search."

15. INCLINED PRESSES. In the press shop particular attention should be paid to the use of inclined presses. It will often be found

FIG 26

This picture shows that the operator is wrongly seated from the point of view of operating the handle of the drill press This handle should be extended so that when the drill is at its maximum travel, the hand is level with the operator's elbow, thus the arc of travel would be from elbow level to shoulder level and return

that these are used as verticals, with the result that the parts have to be removed by hand instead of falling into bins from the inclined base, thus taking advantage of the law of gravity. Even where the

press has to be used as a vertical, nevertheless, a chute or slide should be incorporated for the speedy location and removal of parts

The observer's aim (and supervision's) should always be to reduce the amount of time spent on feeding machines, thus concentrating on machine efficiency.

16. HANDLES OF DRILLS Drill handles cause a considerable

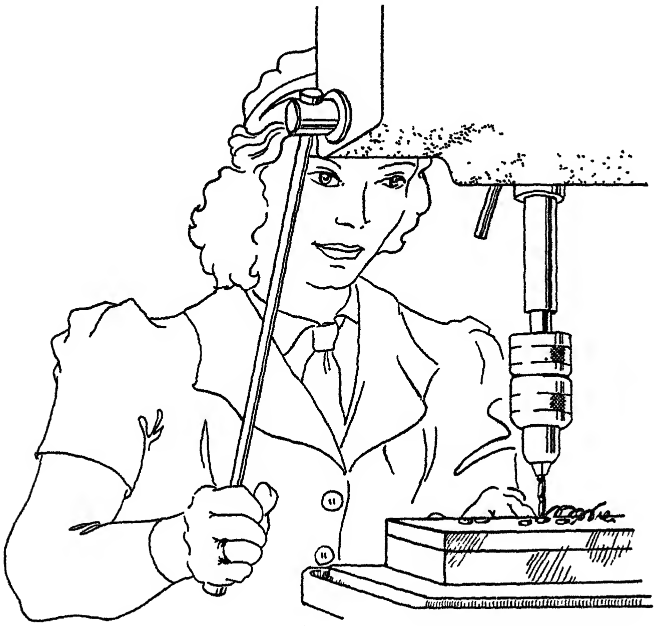


FIG 27
Compare the easy posture of the operator in this action drawing with that shown in Fig 26

mount of unnecessary fatigue. This is principally due to the fact that the setter when he sets the machine is operating it for himself, and does not pay due regard for the operator who is to use the machine all the time, with the result that, although the operating handle may suit the setter, it does not necessarily follow that it will suit the operator. Another point, too, is that, although the operating handle can be used in its existing position satisfactorily by the setter, the angle of the handle itself may be such that, spread over a long period, it will cause strain due to extended reach. The illustration (Fig. 26) shows this clearly. Here, it will be seen, the operator's arm

is extended almost to the full limit, which has brought her shoulder into an unnatural position, with the result that the muscles, because they are unaccustomed to such strain, will naturally ache and therefore predispose towards extra fatigue

B. Sub-assembly Lines

1. Poor Bench Lay-out. A separate section (see page 163) is devoted to bench lay-out, but at this juncture the observer's attention should be drawn to the fact that the description "poor bench lay-out" can be equally applied to assembly benches, sub-assembly benches, machine benches, machine tables, and even machine beds.

If the bench has been laid out without due regard for the convenience and ease of operation by the operator, then a considerable amount of time is lost in searching for tools, parts, components, etc.

2. Lighting. The same remarks apply here as to the previous analysis of this factor

3 Hand Tools instead of Power. Under this heading, the observer should take particular notice of the tooling situation. In a very great number of cases, hand screwdrivers and box spanners are used where air-driven or power-driven drivers and spanners could well be used instead. Even if the assembly of the part forbids the use of power (i.e. where stripped threads are common), nevertheless, a Yankee screwdriver or box spanner can be used, and it is quite unnecessary, and an unfair burden these days, to ask an operator to use out-of-date tools, involving as they do extremes of energy dissipation. Under this heading, too, can be classed hand files where rotary files can be used, hand soldering irons where automatic "Stanelco" units can be incorporated. (Apart from the saving in time and energy, there is also the point to be considered of a more efficient join, dry joints being almost unheard of where automatic soldering is employed.)

4. No Fixtures. A great deal of wasted effort is shown in the use of one hand as a vice, where the left hand is being used to retain a part that is being assembled. This almost halves the efficiency-potential of the operator The number of parts that cannot be held in a fixture must represent a very small proportion of the whole, and where the jig and tool design is so weak that the operators are left with the alternative of holding parts with one hand, and risking an accident with a screwdriver through not holding the part rigid, it is surely a grave reflection on the efficiency of the methods department and supervision.

5. Small Parts Located in Boxes. Another common cause

of wasted time is that small parts, such as nuts and washers, shakeproof washers, spring washers, small pins, seals, etc., are located in boxes on the bench. Boxes with vertical sides mean that the operator will inevitably pick up a handful of parts and strew them over the bench, thus involving the operator in searching for the parts. A very small amount of concentration is required to decide that boxes with sloping-forward sides will enable the operator to pick the parts out with one finger, thus eliminating untidy benches and waste of time in "search."

6. Poor Inspection. Wasted time is found where operators have to indulge in selective assembly. This is mainly due to inspection not performing their function efficiently, or where there is a casual check, such as a 5 or 10 per cent inspection of purchased parts. It is not easy to insist that inspection check, say, 100 per cent of every part, but where supervision can see that operators are engaging in selective assembly, some sort of inquiry should be made, so that inspection shall be cognizant of the fact that these parts are inclined to be faulty, and thus instigate a 100 per cent check against the suspected supplier. Indeed, some contractual clauses insist that where a "Goods Inward" inspection needs to be 100 per cent, the time shall be debited against the supplier, and the observer would be well advised to check up if such a contract is in being.

7. Bad Seating. Seating can cause fatigue! If the sitting position is ill-formed, maladjustment of the natural position will result. This reflects itself in operator inefficiency, caused by backache and muscle strain. Where the operators have to stoop over the bench because the seat is too high, or stretch their backs because the seat is too low, then these are obvious causes of unnecessary fatigue. There are several specialist firms who concentrate on the production of adjustable seating, and any firm who engages in negotiations with one of these organizations will find itself handsomely repaid Correct seating means happy employees; of this there is no doubt. However, a word of warning is necessary. The "purist" will try to change the sitting posture of all operators, and while this is no bad thing in the case of young operators, where the operator is elderly, a change of habit is likely to lead to the reverse of efficiency. Operators who have reached middle age will not take kindly to suggestions that they should alter their set habits of sitting.

8. Ill-balanced Operator Times Delays on sub-assembly lines are invariably caused through the ill-balancing of operators. Work is often given which varies in time between operator and operator. A more detailed analysis of this will be found in Chapter

XIV, page 194. This analysis, however, refers to the efficiency time values of individual operators, and indicates how a line may be balanced. There is, however, yet another reason for flow delays, and this is due to the fact that some operators are not so fast working, with the result that the subsequent operation is delayed. The only sure remedy, of course, is either (*a*) to train the operator to an efficient standard, or (*b*) to remove the operator. Of course, in a well-run factory, the operator-selection tests would have taken place, and this operator would not be on a fast-working line anyway. However, sickness, or lassitude, or other causes do tend to slow down individual operators, and if it looks like being a temporary state of affairs, it is sometimes advisable to overload that particular operation with operators in order that a float may be accumulated before a subsequent operation. If an incentive scheme is in being, naturally this action will tend to reduce bonus, and must be countered.

9. POOR FEEDING. Operators will be found doing their own feeding Needless to say, this is wrong. If an operator is to be paid for special skill and experience, it is folly to allow the same operator to provide his own supplies, and the utilization of labour is obviously incorrect Service labour should be used in feeding bench lines in all cases

10. PHYSICAL TRANSPORT. Another time-wasting factor is that of transport between operator and operator, e.g. where an operator places a part aside and the next operator picks up the same part, where operators place parts into trays and the trays are carried to another operator; where operators receive parts from a previous operator and have to reach for them. All of these are unnecessary burdens, and represent a costly dissipation of energy, time, and skill. (See also page 184.) The provision of conveyor belts, or grid rollers, or even of simple wooden chutes, will do much to eliminate this waste. Objection is often raised to the use of chutes on the score that as the parts arrive at the bottom of the chute they are likely to be damaged through bouncing on the wooden partition A Sorbo or a rubber buffer will have a cushioning effect and will do much to remove this prejudice.

11. EXTENDED INSPECTION. Line inspection is as important in sub-assembly work as it is in the machine shop Where groups of operators are working together in producing one component, if line inspection do not institute periodical checks, the accumulation of rejects unfairly penalizes the good operators, because in sub-assembly work it follows that as the work travels from operator to

operator, the reject is merely built over or is hidden. Thus, where a check or electrical test takes place, the whole part becomes a reject and has to be stripped down, so involving other people's work in addition to the one operator who caused the reject. It is for this reason that periodic checks on the line do much to save wasted time and labour. It is not suggested that this should take the place of final inspection, but it is a good plan to insist on inspection doing a time check in order that if faulty material is being used or a faulty operation made, then the job can be stopped before too much damage has been done.

12. LARGE GROUPS. Large groups have a tendency to reduce output. It is a safe assumption that the larger the group the smaller the ratio of individual operator efficiency. This is due to the multiplication of delays, material errors, floats, lack of efficiency, speed, etc. To gain the maximum efficiency, if jobs must be grouped, they should be grouped into not more than seven or eight operators. This allows full scope for the individual operator to feel that his effort is worth while and that "passengers" are not encouraged.

13. POOR PROGRESSING. There should be no excuse for poor progressing. This, involving material delays, deprives the operator of any real incentive or interest in the job, and prevents the function of skill and speed. It is better to have the operators idle for a short period while material is being accumulated, than to have the operators working at a low speed in order to extend the time spent on dealing with "shorts."

C. Service

(*a*) INSPECTION

1. *Text Gear.* A common fault in sub-assembly and final assembly shops is that the test gear is not located near the line. This means trucking parts from the operator to the inspection line, and then trucking into stores This is wasteful, because it ties up service labour and it increases the time lag between work completed and inspected Where possible, the test gear should be situated near to the point of assembly.

2. *Measuring Instruments* Inspectors often use measuring instruments, such as micrometers and vernier gauges, in the mistaken belief that these are necessarily more accurate than gauges. This is not true. A well-made gauge will do the work more efficiently, and reduce the cost of replacement. Another important point to bear in mind is that where micrometers and verniers are used, inspectors, being fallible, often reject parts without justification. Gauges,

particularly of the "go" and "not go" type, are more reliable, and they save time, due to the fact that adjustments to instruments do not have to be made during inspection. Micrometers and other instruments with a mirror surface need to be handled carefully, and this may introduce yet another element into inspection, which is the "care" element, thus slowing down the actual job.

3. *Gauges*. Where there are a number involved, gauges should be anchored, i.e. they should be situated either in racks or boxes, on pins, so that the operator does not spend needless time in searching for the right gauge.

4. *Ill-balanced Flow*. Flow is as important in the inspection lines as it is on the assembly and sub-assembly lines, and for this reason the time study man should spend some time in reorganizing the operations connected with inspection. It is as wasteful to have one inspector piled up with work as it is to have an operator overloaded on production. Therefore, time spent on breaking down the job into clearly defined time values will be profitable in its return to the organization of time saved.

5. *Handling*. Inspection benches, too, suffer from a lack of attention, inasmuch as these are ill-designed, with the result that parts are handled too much; as in the same way that the operators handle parts where chutes and conveyor belts could be used, so also inspectors suffer from the same time-wasting factors, and in this connexion chutes, conveyor belts, etc., all should be brought into play in order to reduce the time spent in handling. (See also page 183.)

6. *Line Inspection* It is important that inspection take checks on the line from time to time, and in this connexion it is necessary that there shall be some records kept. Not only will these records provide valuable data for a reject analysis report, but they will "spotlight" the cause of rejects *at the time*. This "spotlighting" will enable steps to be taken immediately to remove the fault, whereas if the inspection check is left until the end of the assembly, very often so many parts have gone through that either a great deal of time is spent in tracking down and assembling or a concession has to be obtained, both of which are wasteful.

7. *Insufficient Standards*. Another common fault in the inspection department is that the standards are either insufficient or not clearly defined, and very often too much reliance is placed on the individual's conception of a good part. This is true of those jobs where measuring implements are inapplicable; for instance, on soldering joins where the visual inspection is to decide whether or not it is a good join. It is advisable to have specimens provided in order that both the

inspector and the line supervision may be acquainted with the standard of work required.

8. *Non-segregation of Faults.* A common fault with the inspectorate is to lump all the rejects together in one whole. This non-segregation of parts leads to a repetition of inspection's work, due to the fact that if the parts have to go back to different operators, then the parts have to be looked at carefully in order to determine which operator shall remove the difficulty. It is easy enough to see that any system of part segregation will be worth while, and it is advisable that inspection should have bins properly labelled so that the parts can be immediately sorted and returned to the operators, thus obviating time-wasting factors in re-inspection, or delay on the part of operators who have to examine the component carefully to determine the fault. Some organizations use labels for this purpose, but this is not to be recommended, due to the fact that labels have to be written out, which takes time. Also they have to be tied on to a component and taken off when the reject is attended to, and the waste time and material involved is something that the motion economist will wish to avoid. Therefore, bins, with a brief description of the reject written on, will provide a solution.

9. *Immobile Inspectorate.* Inspection, for some reason or other, seems to like immobility It is a common fault of the inspectorate to have a bench for themselves and to wait there for the work to arrive That this is a fault cannot be denied, and inspectors, to perform their work efficiently, should be mobile, i.e. they should be able to move to the parts rather than the parts moving to them.

(*b*) TRANSPORT

1. *Congested Gangways.* There is no doubt that congested gangways cause delays, particularly where any degree of trucking takes place. Floor space is valuable in any organization, but due regard should be given to adequate spacing of the gangways, not only from the point of view of trucking, but also from the point of view of reducing accidents, since congested gangways must also cause confusion during which operators can easily harm themselves on projecting machinery and the extruding bar racks.

2. *Manually-propelled Trucks.* If the organization is sufficiently large, then all manually-propelled trucks should be scrapped in favour of mechanical trucks. There is no point in dissipating manual labour when, for a comparatively modest outlay, all trucks can be self-propelled.

3. *Transport "Empty."* A common cause of waste in factories

is transport being empty, that is trucks travelling from one point to another without a load, whereas planning should insist, where possible, on trucks travelling with a load.

4. *Pick-up Points.* "Pick-up" points lead to the more efficient distribution of transport and do much to eliminate No. 3 above. If there are no pick-up points, it means that as the parts accumulate on the lines they have to be trucked away. This leads to line interruption—if not actual physical interruptions, certainly to distractions. Whereas, if the service labour could remove the parts as they accumulate to definite pick-up points, then the truckers could remove these parts to their destinations without operator distraction.

5. *No Pooling.* In factories where lifts are being used, pooling is often absent. Pooling is the assembly of parts going to the same destination. If pooling is adopted, it will be found that it reduces the number of empty lift journeys by a considerable amount (one experiment in the author's experience reduced empty lift travel to 2 per cent).

6. *No Time-table.* Time-tables should always be used. This obviates rushes where priorities become a matter of importance. The time-table is prepared by the progressing department, who not only determine at what time shall the parts be completed and inspected, but also indicate at what time the parts should be deposited by the lift ready for collection. This adherence to a time-table enables progressing to eliminate many of the inefficiencies associated with trucking.

7. *Manual Supply instead of Conveyors.* In a large number of organizations, overhead conveyors can take the place of trucks and should be used wherever possible. They free floor space, they enable parts to be delivered "spot on" to their destination and, what is more important, they reduce labour costs. (See Fig. 28.)

8. *Wrongly-designed Bins.* Organizers of transport would do well to study bin design. If bins are to be loaded on to trucks, they should be so designed that when full they will stack neatly one on top of the other, and when empty they will sit one inside the other, thus increasing the carrying capacity of the trucks.

(*c*) STORAGE

1. *Bins instead of Tote Pans.* It is very often found that bins are used in stores instead of shallow pans loaded on racks, which means that as parts are required they have to be extracted from the bins, loaded on to boxes or trays, and then passed to the trucker.

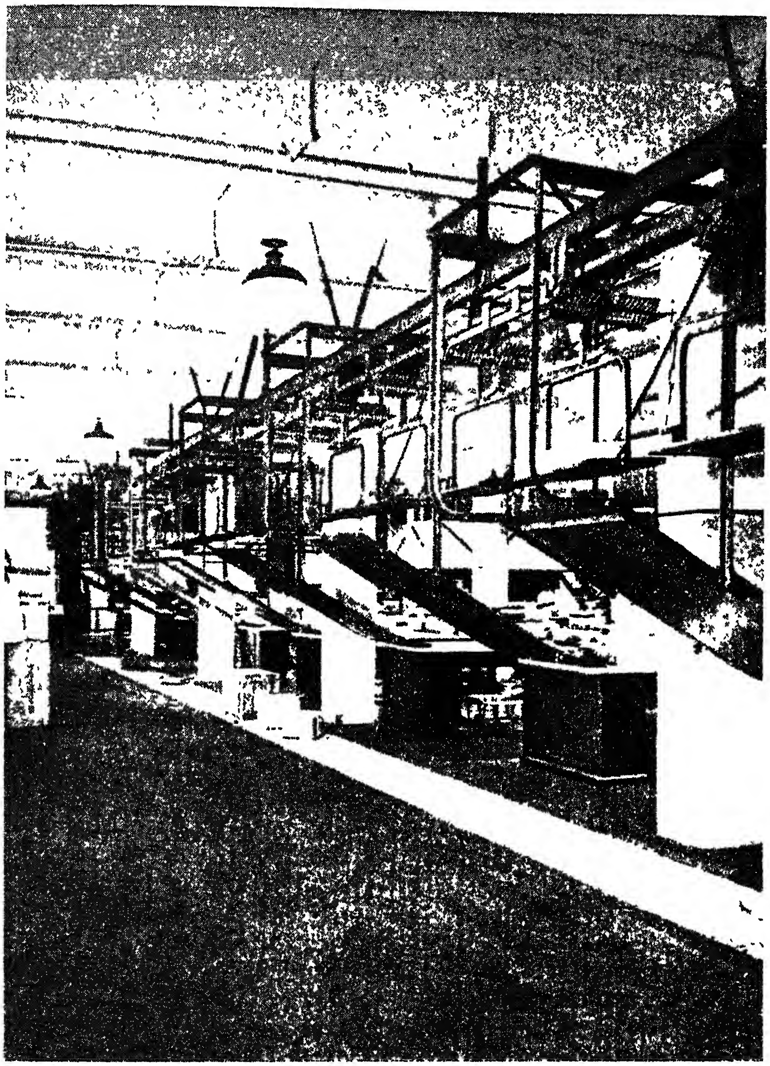


FIG. 28

The photograph shows a system of overhead delivery chutes, the delivery points can be predetermined. This picture is remarkable for the illustration of complete avoidance of floor congestion.

(By courtesy of Sovex Ltd.)

Whereas, if the parts are located in shallow pans with the number of parts the pan contains marked on the side, it will be an easy matter to transfer the number requested without any delay

2. *Portable Ladder instead of Rolling Platform.* Where the place of storage is high, it is customary to use high-level racks, which are reached by means of a ladder. This is wasteful, because as the various parts become due, the ladder has to be moved to and fro, whereas if a platform were mounted on anchored rollers, the platform could merely be pushed along, and thus reduce the waste of time and at the same time remove one of the hazards usually associated with portable ladders.

3. *Manual Transport instead of Grid Rollers* Man-handling parts from stores to the serving hatch takes time, and this could be well done on a conveyor system.

4. *Serving Hatch at End instead of at Centre of Stores.* It is surprising the number of times one sees a stores serving hatch situated at the end of the stores, whereas it should be at the centre, allowing equal distances on either side for storage, thus eliminating waste time

5. *Rapidly Consumable Parts* Another form of economy that can be practised is to place the rapidly consumable parts near the hatch, so that the time spent in loading and unloading is reduced to a minimum.

6. *Card Index Records instead of Wall Chart* A wall chart indicating (*a*) where the parts are located, and (*b*) how many parts there are left, will save a great deal of time. Normally, only a card index is used, and, if numbers are the normal means of recognition, the numbers have to be reconciled with the part and then looked up on the card index. If a name is used, this too means that the part has to be recognized and then looked up on the card index also.

7. *Serving Hatch instead of Stable Door.* The serving hatch should be of the "stable door" type so that heavy parts do not have to be lifted over it, but can slide in. This occurs in a great number of factories, with a consequent reduction of efficiency.

8. *"Take" and "Give" Using Same Hatch.* Another economy that can be practised is to have two hatches instead of one, so that people taking material from the stores and people delivering material to the stores do not use the same hatch. This avoids queueing, and, of course, saves a considerable amount of time.

9. *Counting instead of Weighing.* Where a large number of small parts are concerned, the number can be easily found by a ratio-weighing machine. This saves a useful amount of time that would be normally spent on counting, and is accurate for most purposes.

(*d*) CLEANING

1. *Degreasing.* It is still a common procedure in factories to use manual means of lifting parts in and out of the degreaser. Where an open degreaser vat is used, it is more than ever necessary that a hoist should be fixed (an ordinary simple rope block and tackle should suffice) over the vat, in order to prevent the operator wasting his strength in overcoming the law of gravity when lifting both in and out of the degreaser. Apropos of this factor, it is of course a physiological fact that exertion causes people to breathe more heavily, and it is apparent that if an operator is bending over an open vat and struggling with the control of a heavy part, the amount of physical exertion involved causes him to breathe in the vapours, which may have a deleterious effect on health.

2. *Fettling.* There are very few parts manufactured in the shops to-day where only hand-fettling can be used. Where possible hand-fettling should be transferred to fettling by mechanical means, and a good illustration of this is one of the many flexible power-driven tools. In these days of highly mechanized industry, there is surely no excuse for burdening operators with hand tooling!

3. *Sweeping of Floors.* This should not be done during working hours. The reasons are so obvious that one wonders why so many factories do not insist upon this rule being observed. A few reasons are—

(*a*) Sweeping interferes with operators' and truckers' movements

(*b*) It raises dust, which causes operators discomfort.

(*c*) The same dust settles on parts which may have to be kept clean.

(*d*) Sweeping cannot be efficiently performed during operator hours due to the rapid accumulation of floor waste immediately after the sweeping has been done

There is no reason why sweeping should not be done during breaks, particularly at night, which gives the dust an opportunity of settling, without causing discomfort to the operators

4. *Gate Breaking.* This is often done with a hammer when, of course, an arbor, tooled up, to press the part out from the gates, would not only do the job more efficiently, with a consequent saving in time, but would also help to reduce rejects.

5. *Flash Removal.* The removal of flash should not be done any more with a hand file. There are many rotary files, power- or air-operated (or again an arbor press, properly tooled), which will remove the flash, the actual method of removal, of course, depending upon the numbers involved.

6. *Deburring*. Where the parts are dimensionally small, "offering" up to a drill is an easy and economical way of deburring. Where they are large, a portable electric or air drill performs the same function. Using a metal scraping tool is too wasteful of energy.

7. *Swarf Removal.* Removal of swarf is often done by using a hand brush, but if the factory is equipped with an air compressor, the blow gun will be found much more efficient.

8. *Baling*. Those firms which have a considerable amount of baling to perform will doubtless have considered the respective merits and demerits of a mechanical compressor. This is very much an advantage over the hand-baling methods which involve such a considerable amount of physical strain on the part of the operators. It helps to reduce accidents.

9. *Scrap Sorting*. Unfortunately, scrap sorting is inevitable, but worse than this, a considerable amount of time is invariably spent on sorting scrap where, if pre-segregation had been instituted, much of it would not be necessary. Pre-segregation is very simple. It merely consists of a series of bins in each shop, respectively labelled · "lead," "copper," etc As the scrap accumulates, so the truckers can remove it from the machines and deposit it in the appropriate bins. This is an economy which is very well worth while.

D. Final Assembly

Where the final assembly lines involve really large assemblies, such as the assembly of chassis on the conveyor system, a close attention to the following points will more than repay the time spent.

1. PORTABLE TOOL TABLES. These are tables upon which are racked tools that will be necessary for the assembly work. They should be allocated to every six or seven operators according to the nature of the job. They will carry those replacements which are required from time to time by the operators. The system works on the principle of swift change in order to reduce the time lag consequent upon operators having to go to tool stores to obtain new tools. It must be remembered that any time lag on the conveyor system reacts unfavourably upon the whole line.

2. POWERED TOOLS. Again attention is drawn to the use of powered tools in favour of hand tools. This particularly applies to drivers and spanners. On the conveyor system, the power points should be established by pre-planning so that the operators can just plug in as required. Where drilling is an operation on this section,

care must be exercised in the choice of tool. There are many small "pistol" type drills, but some have more merit than others in the ease of handling that they afford. This is a point to bear well in mind when choosing the type of tool. The "handier" the tools, obviously the less fatigue that is engendered.

3. BLUE-PRINTS. On line assembly of comparatively small parts, the use of blue-prints should be avoided. It is far better to have a "mock up" made of the part so that it is easier to follow. This also will establish the standard that is required and so help to reduce rejects. Where the larger assemblies are involved, the use of blue-prints is usually inevitable, but even these can be simplified. Where possible (remembering that the labour is often "green"), an exploded drawing should accompany the blue-print; this is an aid to easy recognition.

4. SUB-STORES. A rapid consumption of parts means that a sub-stores needs to be situated near the line. Drawing from a main stores may help in stock control, but it means a considerable waste of time by the operators who have to wait for parts. The sub-stores, in effect, will be carrying a float, so that the operator will always have a buffer against a shortage—no mean consideration when the whole line is dependent upon one operator.

5. SHADOW Much time is lost during the assembly of large and awkward parts, but the groping in dark corners after elusive nuts and bolts is usually due to unexpected shadow. One excellent way of overcoming this is either to have a portable inspection lamp literally on tap or to issue each operator experiencing this trouble with a head lamp of the miner's style so that it can be switched on in an instant. These are useful, too, when it is not yet necessary for the whole shop to go on to artificial lighting, but the individual operator finds some sort of lighting aid necessary

6. ANGLE TOOLS. The provision of angle tools is yet another problem. Very often the process lay-out department has overlooked the need for these, or, due to a previous mis-assembly, there is already a bolt or other protruberance in the way of easy location. In these circumstances, where the provision of angle tools is necessary, the tools can be located on a portable tool table so that no delay is occasioned by the creation of such a condition.

7. TOOL BELTS. On those assemblies where the operator has to do interior work, the provision of tool belts will be found to speed up the job materially, due to the elimination of the "search" aspect of tool selection. Another distinct advantage is that the operator does not lose any time due to "plumber's memory."

8. SELF-TAPPING SCREWS. Self-tapping screws are not used nearly as much as they deserve. In a large number of cases this is due to prejudice, and the observer would do well to investigate the reason where this seems to be the case.

9. CORED SOLDER. The question of using cored solder has already been discussed, so it is sufficient to say here that where the need for soldering is proved, the provision of cored solder should be automatic.

E. Feeder Shops

(*a*) DIE-CASTING. In this section there are two great and notorious thieves of energy and they are weight and heat.

1. The overcoming of the energy expenditure in handling weights gives food for thought. It can be overcome, but it is not an easy problem to solve. Perhaps the greatest saving can be accomplished by the elimination of the trucking of the ingots. These are usually unloaded at a spot adjacent to the die-casting machine, loaded on to a trolly, trucked to the machine and then loaded into the melting furnace. All this labour can be overcome by the use of an overhead conveyor serving a battery of machines. This is accomplished by means of a feeding gantry fixed above the furnace and, as replenishment of metal becomes necessary, so a predetermined amount is permitted to slide in. Particular attention must be paid in the design of this to permit the gradual sliding of the metal, otherwise the consequent splash will prove dangerous.

2. Heat fatigue is one of the greatest drawbacks to efficiency in the die-casting shop. This is caused by the rapid evaporation of the moisture in the body. One method of overcoming this is to supply sodium chloride tablets which are washed down with water. There are several brands on the market, and one of the latest developments in this field is a tablet so coated that it is not absorbed by the stomach, thus removing any unpleasant reactions. The provision of "blanket" room will aid in the prevention of chills consequent upon the operators leaving a hot atmosphere during breaks. It is advisable to insist that this is made use of, not in the employee's time, but in that of the employer's, otherwise this precaution will not be taken.

3. Die removal is an operation that is not often taken care of by the planning department. The use of a tommy bar in this connexion shows that sufficient thought has not been given to the design of the "spin off" tool. A brace type of spin tool is by far the best, the reduction gear of the brace giving greater power with less energy dissipation by the operator.

4. Breaking gates whilst the metal is hot has one merit in that the material is more pliable; its disadvantage lies in the fact that gloves to protect against burns must be worn, which distract from efficiency. There seems to be no cogent reason why the gate breaking cannot be done mechanically and cold. Certainly if this was made a separate operation, the result would be that the labourer would be able to spend more time in servicing the machine operator, with a gain all round.

5 Where the cast parts are binned right away, it is advisable to fit the bin with a chute both for feeding the bin and for when the parts are to be trucked away, the labour involved in transferring the parts from the bin to the truck is thereby reduced. If one side of the bin is hinged, then this also helps in disposal, since the side can be lowered away and the part shovelled into the truck according to its capacity. When the bin is full, of course, this operation would be even more simplified by a system of double hinges, so that the side folds back on itself, the parts falling into the truck by sheer force of gravity.

(*b*) BAKELITE MOULDING. Here is an entirely different technique. It must be remembered that the actual mould leaves the Bakelite press and thus is subjected to a cooling-off process Therefore the more time the mould takes to prepare, the greater time must be given to the cure period in order to recoup the lost heat of the mould

1. One important part about the mould is its weight. Chutes should be used on every occasion in order to reduce the fatigue accruing from handling the weight. Duplicate moulds should be used so that inserts can be loaded and the mould prepared whilst the other is undergoing its cure. Therefore, in order to conserve heat, some form of auxiliary heating should be employed. (See Fig. 29 and table on page 150.)

2. Another time-saving economy that can be introduced is the provision of individual minute clocks with alarms. Some organizations rely upon a "master" clock which all operators can see. This is all very well, but it leads to operators waiting for the hand to reach the full minute before starting the cure, and this imposes quite a delay in the operation of the machine.

3. Inserts are invariably tapped out with a hammer and tool. A worth-while economy that can be practised is to supply an arbor press tooled up so that all the inserts are pressed out in one go. Here is a comparison. Suppose that the mould contains four cavity formers; each former takes an average of five taps to remove; we then have to select tool, grasp hammer, tap to free (four off) aside

TIME COMPARISON OF TWO METHODS

METHOD I

No.	Element	Time (flat) Minutes
1.	Switch off and lift cage	0·08
2.	Open gates	0·05
3.	Extract mould and take to bench on left	0·13
4.	Drop on fixture and shake top free	0·07
5.	Turn base over, pick up hammer and punch	0 08
6.	Tap out inserts (4 off). These fall to bench top	0 18
7.	Aside hammer and punch, turn over base	0·09
8	Up measure of Bakelite powder, locate and return measure	0·07
9.	Up inserts and locate to base (4 off)	0·12
10.	Up top and locate over base	0·08
11.	Take mould to press. Close gates	0 17
12.	Drop cage and switch on	0·07
13.	Set clock for cure control	0·04
14.	Cure time — Fettling (4 off) = (2·0 — 0·68)	1·32 P.A.
		2 55 mins.

METHOD II

No.	Element	Time (flat) Minutes
1.	Switch off and lift cage	0·08
2.	Open gates	0·05
3.	Extract mould, slide to pivot tray, swing to hot plate "A." Slide on hot plate and leave	0·15
4	Turn cross work area (2 steps), pull pivot tray with prepared mould and slide to press	0·13
5.	Push in, hook pivot tray out of way, close gate, drop cage, set clock switch on (leave tray)	0·19
6.	Turn to "A," shake top loose, turn mould over, slide to arbor bed	0·15
7.	Press out inserts (one operation). Inserts drop to bench top	0·06
8.	Slide mould back to hot plate, turn over	0·07
9.	Up 4 fresh inserts, up tablet of Bakelite powder and locate	0·13
10.	Up top, locate over and leave prepared mould on hot plate	0·07
11.	Fettle inserts by hand and drop to chute	0·68
		1·76
	Cure time 2 mins — 1·76 (total elements)	0 24 P A.
		2·0 mins

Comparative Method I · Time allowed 1·06 hours per 100
Comparative Method II: Time allowed 0 835 hour per 100

NOTE The cure time in Method II will probably be reduced due to the constant heat from the hot plate.

The above analysis shows that whereas in Method I the operator had on less than 1 32 minutes non-productive time, in Method II this is not only reduced to a bare 0·24 minute, but extra work has been performed.

BAKELITE MOULDING: PREVIOUS :- Method One

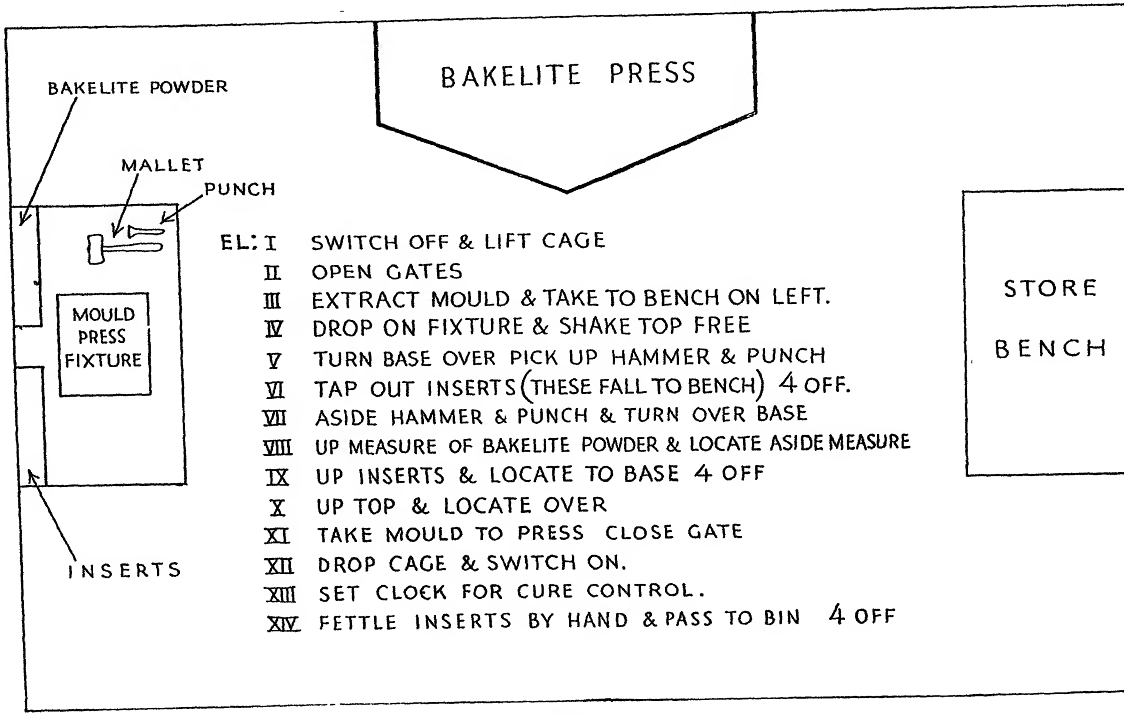


Fig 29A

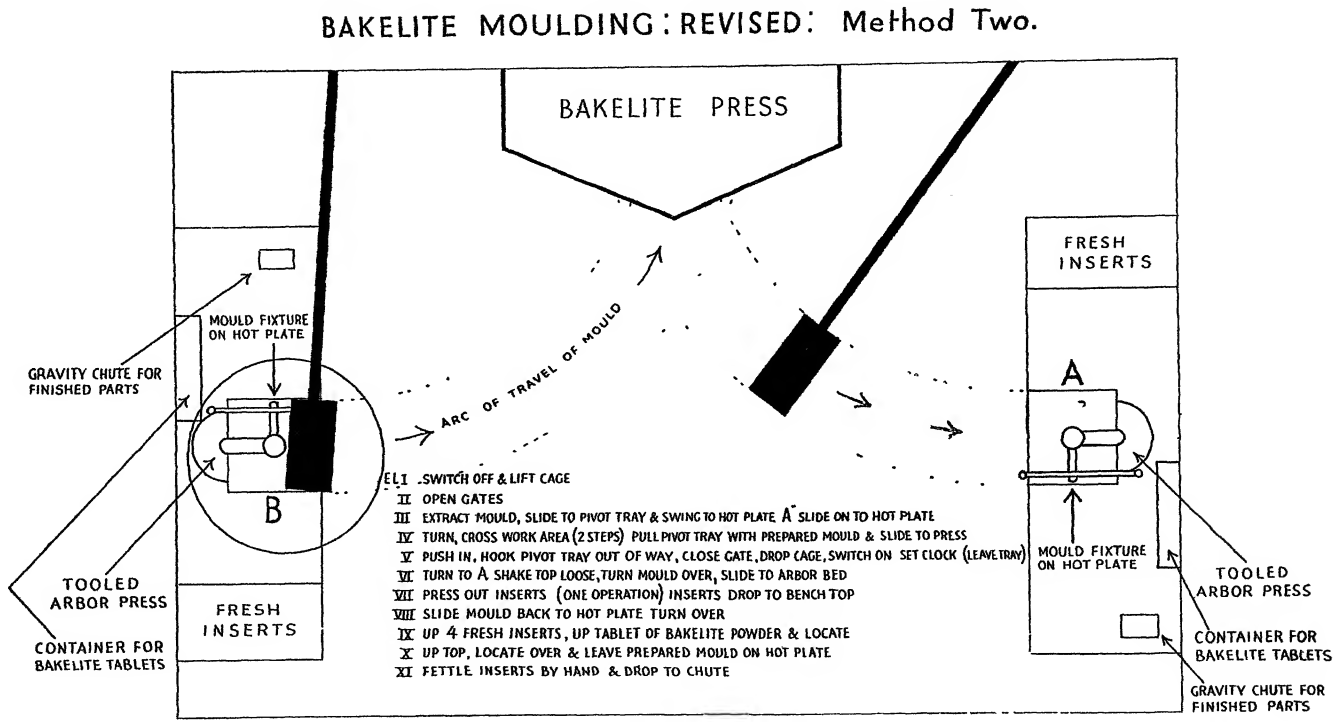


FIG 29B

The provision of alternative moulds, together with some form of pivoting trays, will materially speed up Bakelite moulding, and cut down the time lag between the mould leaving the press after curing and being returned—a most important consideration in connexion with machine loading efficiency

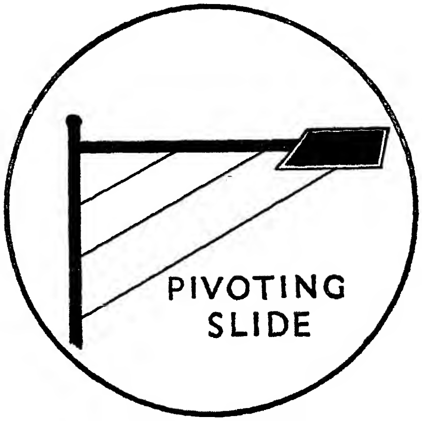


FIG 29C. DETAIL OF PIVOTING SLIDE

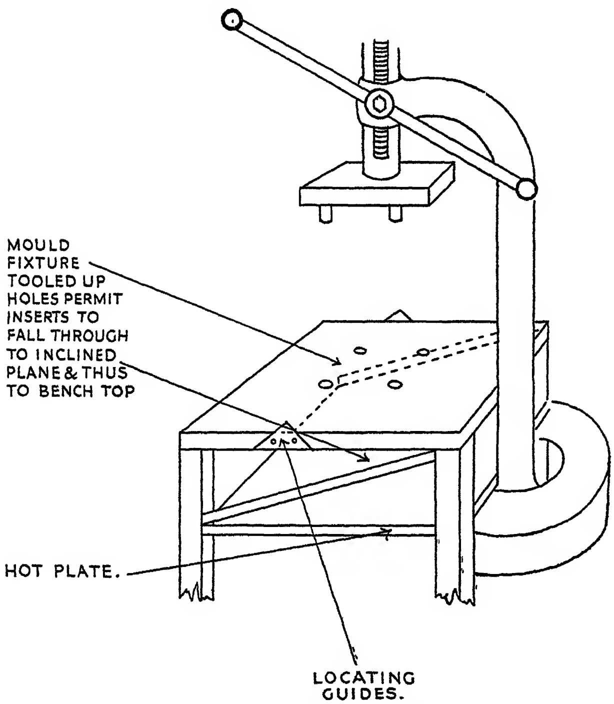


FIG. 29D DETAIL OF TOOLED ARBOR PRESS

hammer and tool. At the rate of 14 moulds an hour, for 10 hours a day, this gives a total of 3360 motions.

On the other hand, the sequence would be taken to press (instead of bench), locate, swing handle of press and extract mould—a total of three motions as against the 24 previously listed. For 14 moulds per hour and 10 hours per day we have 420 motions, a saving of nearly 88 per cent!

4. Another saving that can be made is the preparation of the powder in order to eliminate the measuring or weighing at the time of operating. This can be done either by having the powder weighed up into small paper containers which can be *torn* so that the powder runs into the mould, or, alternatively, the powder can be compressed into tablet form and located straight into the mould. This latter is the better from the point of view of saving time, but both show a saving.

5. The duplication of moulds, as demonstrated in Fig. 29, is important. Not only from the time-saving point of view, but, because these tools are valuable, they must receive constant examination. Thus, in order to keep the machine running while the tools are being inspected, the duplication of tools is a vital necessity.

6. Moulds which contain threaded inserts will need special attention in this matter of economy. One of the most common methods is to use a spinning tool equipped with a tommy bar for the extraction. The incorporation of a bench fixed brace will serve the same purpose with greater expediency. There is every reason to use a tool similar to this, but the greatest reason is the fact that, during a cure time, the operator, if he is to get the greatest amount of work out in preparing for the second cure, must cut down the time. The brace method certainly does this, and is to be recommended for all but the most delicate threads.

7. Properly planned, the removal of flash and the fettling of threads and holes can well be done during the cure time. If the operator is idle during the cure time, an allowance will have to be made on the time study value to cover this, since obviously the operator *cannot* earn bonus while he is idle. So that if the flash removal can be done after the preparation of the second mould and during the cure time, then the bonus can still be earned instead of an *ex gratia* allowance being made as compensation.

F. Paper Work

The paper work of a factory needs constant attention to ensure that redundancy is not endured for the sake of habit. Another

cause of waste is the tendency to create paper work to cover contingencies which should, in any case, be taken care of at source. Multiplicity of forms is an evil to guard against, particularly in the progressing department, where there is always a tendency to over-organize

1. A typical time waster is where forms are made out in duplicate or triplicate Here the insertion of carbon paper can be eliminated by the provision of carbon-backed forms. Not only is this an obvious time-saver, but it guarantees that the copies will be taken, instead of relying on human fallibility to see that the carbon paper is indeed inserted.

2. Where descriptions have to be often written up (some obvious examples are time study element writing; checkers' reports; stock controllers' summaries, inspector analysis, etc.), the adoption of codes will reduce the amount of labour required. Printed forms with spaces for ticking off the parts or with facilities for through line deletion, provide yet other alternatives.

3. The issue of individual control cards or sheets provides a prolific field for waste. In general, the issue of data, statistics, charts, graphs, information, instructions, requisitions, specifications, etc., all should be done from "constant masters." These are run off on a duplicating machine, and thus it is assured that everybody receives the same information. The practice of issuing information to heads of departments and letting the information percolate through the various strata of authority is wasteful and leads to constant checking in order to eliminate error.

4. Where paper work has to be issued to the machine shops, the provision of greaseproof envelopes will prolong the life of such paper work. It should be apparent that where no such protection is given, not only does the record suffer from the deleterious effect of oil, but the risk of error is increased due to the smudging of the ink.

5. Forms should be standardized where possible. Not only in make-up should the forms bear similarity, but also in format This renders filing more easy to perform; it simplifies the printing, reduces the cost of replacements, and tends to smooth out the running of a paper work scheme. Easy recognition can be obtained by a system of "flashes" coloured for specific needs. The printing can be done in contrasting colours so that certain forms stand out from the mass.

6. Periodic checks are necessary to ensure that forms have not outlived their usefulness. It will often be found that special forms have been designed for special purposes, yet, when the need has

quite disappeared, the forms continue in existence. A check both by the head of the department and by the stationery department will or should reveal this fault. One way of overcoming it is for the stationery department to issue a questionnaire, which, taking each form in turn, is circulated to the departments concerned, asking for the questions to be answered, usually by means of "yes" and "no" against the points raised.

G. Clerical Labour (Factory)

Since any manufacturing organization must measure its efficiency by output, any labour that is not primarily concerned with *production* must form part of the burden. The amount of this burden must always be expressed in a ratio of production · burden. Any reduction then of the ancillary functions of management must reflect favourably upon the efficiency ratio of the factory as a whole.

The clerical section of the factory is one that can be an over-weighted burden in any organization; it is a problem that must be intelligently tackled if profits are to be made and maintained.

Some causes of waste are—

1. Division of authority. Where a manufacturing concern has a large commercial office staff, it is often customary for the general office manager also to exercise control over the factory clerical staff. Where this occurs, waste is almost bound to ensue owing to the introduction of supervisionary control over the office personnel working within the orbit of his operations. These clerical workers, usually made up of wages clerk, costing clerks, stock clerks, and time clerks, should more properly be controlled by the works management in order to avoid confusion and overlapping of duties.

2. Where the organization is sufficiently large to warrant the rapid transference of data and information, a central mailing department should be instituted; this is to avoid the personnel of the various shops delivering their own paper work.

3. Where clerical personne are employed, they should be separated from the working conditions of the factory, either by the provision of "baffle" screens or by giving them office accommodation. It is too much to expect careful computations to be made under machine shop conditions.

4. Some departments are "watertight," i.e. they have their own statistical labour, time clerks, cost and estimating clerks. They should be "pooled." The pooling of such labour avoids overlapping and ensures an efficient liaison between departments.

5. Where the calculations are standardized there is no reason why "tables" should not be worked out and issued to the clerks. The continual working out of similar equations is both wasteful and unnecessary The tables can be drawn up, duplicated, and issued to all concerned. Apart from the question of time saving, this ensures that standards will be maintained, and such anomalies as one operator receiving a few pence more than another for the same job will be avoided.

CHAPTER XI

MOTION ANALYSIS

In the review in the preceding chapter there has been no mention of the insidious time waster in the form of unnecessary effort and motions. Every job, every part of a job, can be done more efficiently if it is done the right way. What is the right way? That question is the crux of the whole subject of motion study.

Gilbreth spent years determining the right way to perform a sequence of movements; Taylor, too, and in each case these pioneers of efficiency were struck by the dissimilitude of operators in the performance of the same task.

Operators, being individualists, develop their own methods of performing tasks; unfortunately they are not sufficiently well supervised for this interest to be directed into the proper channels, with the result that the methods of performing a function not only differ from the planned lay-out of the job, but will have a tendency to differ between operators performing the same job.

Natural skill and acquired dexterity will make a job *look* right, and the subsequent study proving that the job is *not* right will meet with opposition due to the habit that has already been formed.

Therefore, apart from the detailed list in the previous chapter, the close analysis of the *actual operation* must be done in order that the correct method may be established.

What fundamentals are required to ensure that the correct technique has been employed? Whatever the job is, either most or all of the following must be employed. The degree of employment, either lesser or greater, determines the efficiency of the operation.

1. Reach, select, procure, collect, and deliver are the prime or *preliminary* functions.
2. The use of the tool, the assembly of the sundry parts (involving the above No. 1), and the locking in or mating with sub-assemblies comprise the *producing* operation.
3. Picking up, examining, and placing the completed part on one side completes the cycle of operations.

So the above can be summarized as follows—

(A) Prepare.
(B) Perform.
(C) Put aside

These three divisions form the three fundamentals of any analysis

in connexion with motion study. Of the three, obviously (B) is the most important, since all the efforts of the economist must be devoted to reducing the other two, (A) and (C), to a minimum in order that the greatest productive effort may be the result

Now the operator may well perform all three with dispatch He may even be working under ideal conditions and thus be considered to have reached the optimum in the peak of the production curve Nevertheless, all three fundamentals have one thing in common They all produce fatigue If the fatigue element could be cut completely from (A) and (C), clearly more energy would be left to devote to (B), which is to perform. Naturally, fatigue cannot be completely eliminated, but it can be reduced in all these three functions. If fatigue can be reduced on all three and at the same time the distracting influence of (A) and (C) can be mitigated, then the right route to maximum efficient production is being charted

Before proceeding further, fatigue must be analysed.

Fatigue is a piling up of the waste products in the body. It slows down the brain, decreases reaction, causes the operator to become dull, morose, and sluggish. It inhibits a state of frustration, causes lack of concentration, and is cumulative. Under high pressure, operators may yield high results, but if fatigue is not removed or combated, the cumulative effects will become apparent in a falling off of output, a high percentage of rejects, and friction.

The cumulative effects of fatigue are more difficult to overcome the longer they are allowed to pile up, and while appeals to emotion by means of "pep talks" will maintain output for a period of intensive effort, nevertheless there comes a time when the effects of fatigue will not be denied. The graph on page 160 shows how output was reduced per operator through high pressure of work being spread over seven-day periods for about six weeks. It will be seen that the actual bonus earnings, which can be used as a standard measurement, fell off towards the end of the week, with the result that over all there was a loss in operator-efficiency rather than a gain.

Monotony is a harbinger of fatigue; so are poor lighting, inadequate ventilation, wrong choice of foods, and friction over domestic politics.

Under normal conditions it is overcome by adequate breaks, fresh air, and mental stimulation.

Under abnormal conditions, such as are created by over-schedules, rush jobs, seasonal fluctuations, etc , the combating of fatigue becomes even more necessary, and, of course, much more difficult to eradicate.

So it will be seen that there is a variety of causes to be attacked.

(*a*) *Monotony*. Under some conditions this is almost impossible to overcome, particularly on repetitive work. Operators can be

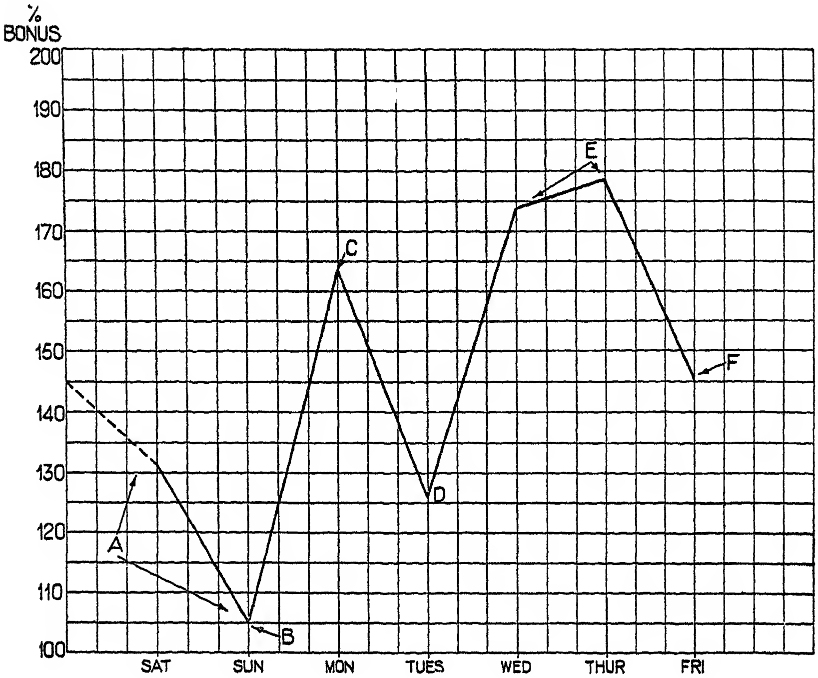


FIG 30

(*By courtesy of "Aircraft Production"*)

A–B shows the fall on Sunday C is the reaction to the shorter working day on Sunday D reveals that the stimulus is not maintained Accumulated fatigue takes its toll. E–F rhythm and habit slowly drag up output F indicates fall which under normal conditions should be absent due to the expectation of a week-end free

N B. 100 = Flat rate efficiency.

encouraged to take an interest in their work by "suggestion schemes," good personnel relationship, sympathetic supervision, music while at work, and stimulation of the competitive spirit.

(*b*) *Lighting*. This should be self-evident. If the lighting is poor, eye-strain and headaches will be the result. This has already been dealt with in the previous chapter.

(*c*) *Inadequate Ventilation*. If the complaints are frequent and if the ventilation is obviously poor, then a firm of air-conditioning

engineers can provide the answer Meanwhile, a thorough airing of the shop during breaks will help.

(*d*) *Friction*. If supervision squabble amongst themselves, if the supervision is weak and allows "domestic politics" to interfere with their work, then this is readily apparent to operators, who tend to take sides, unconsciously or otherwise, sympathetically or not. In any case, this sort of thing rebounds upon supervision.

(*e*) *Food*. If the works doctor gets complaints about tiredness, doubtless he will be willing to co-operate with the canteen in order that the right sort of food is offered on the menu. This side is more properly within the province of the welfare department.

But what of the reduction of fatigue by the elimination of waste effort? That is where the motion study personnel really come into their own. The elimination of waste effort must tend to increase output with less fatigue. Moreover, it enables the operator to earn more bonus with less effort, which is something of real value to the operator.

The detection of wasted motions is no easy matter, particularly as in the previous case mentioned operators develop their own method and a careful study is necessary in order that the operation may be improved.

So, hand in hand with the elimination of waste effort is the reduction of fatigue. This is of benefit to both employer and employee. On one hand the employer is not paying for a tired operator putting forth little effective effort; on the other hand the employee is enabled to do the job well, earn good bonus, and yet finish up the day comparatively fresh, thus eliminating the *cumulative* effects of fatigue.

The object of motion economy is then not to produce more parts in the same amount of time, but to produce the target figure in less time. This is not necessarily the same thing. In one, there is the striving after a total figure with a consequent piling up of fatigue; in the other, the same number of parts are being turned out for less dissipation of energy. Thus the operator is making more bonus because less time is being taken over the job, and at the same time relaxation is greater because there is more free time.

Social experiments have proved, without doubt, that the shorter working day gives the best results. The job of the motion economist is to ensure that the maximum production is yielded in the shortest work cycle.

A study of the analysis listed on page 160 will show scope for improving conditions and. arising from that, the aim should now

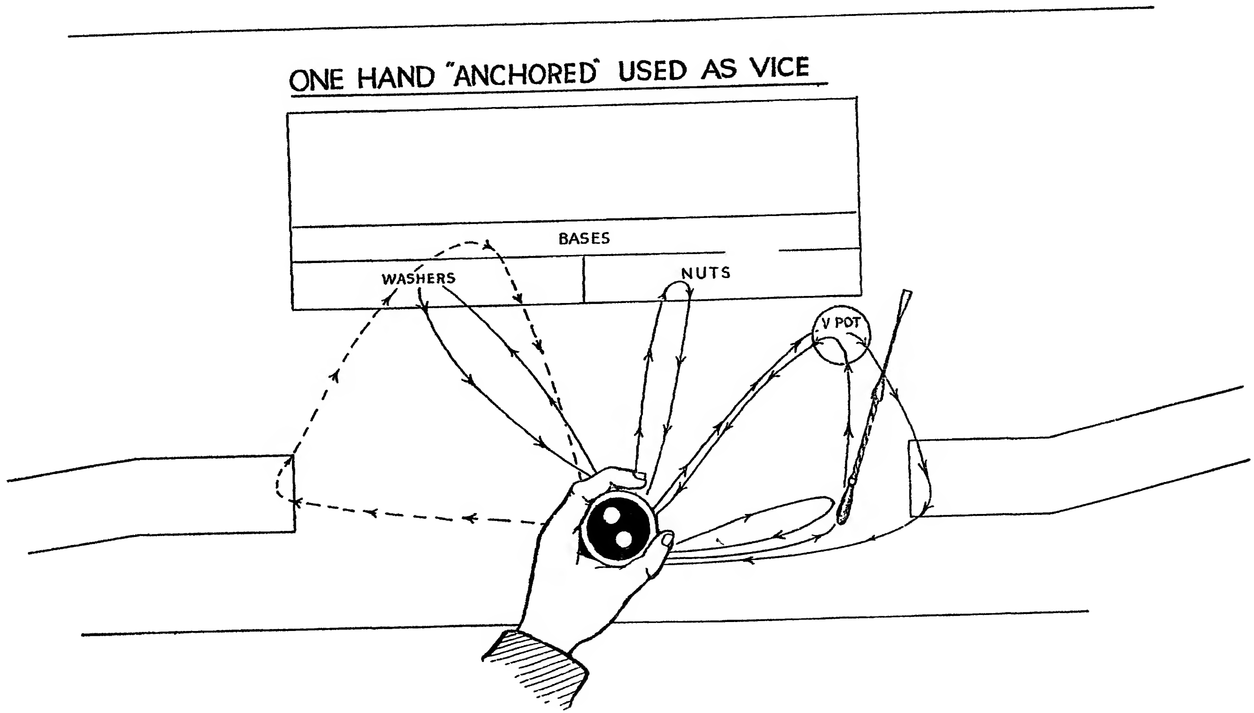


FIG 31

This is wrong. One hand is being used as a vice and is therefore "anchored." This means that the right hand travels to and fro not only unnecessarily, but because it has to cross the body to reach to the left-hand side of the bin to procure washers. It is violating one of the fundamental laws of motion economy

be to find the best way of doing the job. The best way can only be the way that takes the least effort. This is not to presuppose that the time factor will be the lesser Take the case of the Bakelite moulder (Fig. 29B). In this, the provision of a chute reduces the amount of physical effort involved, but it will probably take a little longer to get the mould back into the press This is not a fair comparison, for the provision of dual tooling reduces the preparation time which reduces the *overall* loading time Hence there is a saving in time. But the actual physical act of replacing the mould will take longer than by lifting it back. This, however, is compensated by the fact that, under the original set up, the act of loading gradually built up a fatigue factor which tended to slow down the operator towards the end of the day; this slowing down reflects itself in all his motions, not just merely lifting in and out of the press.

It will be seen that a great deal of stress is laid on the handling time involved. This is because the assembly of components comprises nearly 100 per cent of handling time, and any reduction in this time must contribute a great deal to the extreme limit of economy on assembly work.

The handling of tools and parts demands the closest scrutiny in order that the unnecessary motions associated with these elements may be eliminated. Naturally the lay-out of the bench affects the handling time to a large degree. If steps can be taken to lay out a bench properly, that is, correct from the point of view of easy accessibility of parts and tools (see Figs 31 and 32), the avoidance of crossing the hands by diverse fields of travel, by the incorporation of fixtures to free one hand from being used as a vice, by the adoption of gravity chutes to avoid the necessity for actually placing a part aside, then a great deal will have been done towards the total elimination of waste.

In Fig. 33 will be seen a specimen lay-out of a bench. Here it will be noticed the angle of travel has been considered and also the travel distance itself. On the well-laid-out bench the forearm should not need to travel more than fifteen inches in order to procure a part or tool. Any longer distance than this reduces the efficiency of the operator because such travel is wasted energy and wasted time. (See also sketch in Figs. 31 and 37.)

Figs. 34A and B and 35. Here are two other examples of how extended recoil (and rotary movements) can be demonstrated.

The radial type of bench bin is better than any other type, principally because the peripheral lends itself to the inculcation of rhythm. Rhythm in assembly work is important, and the more

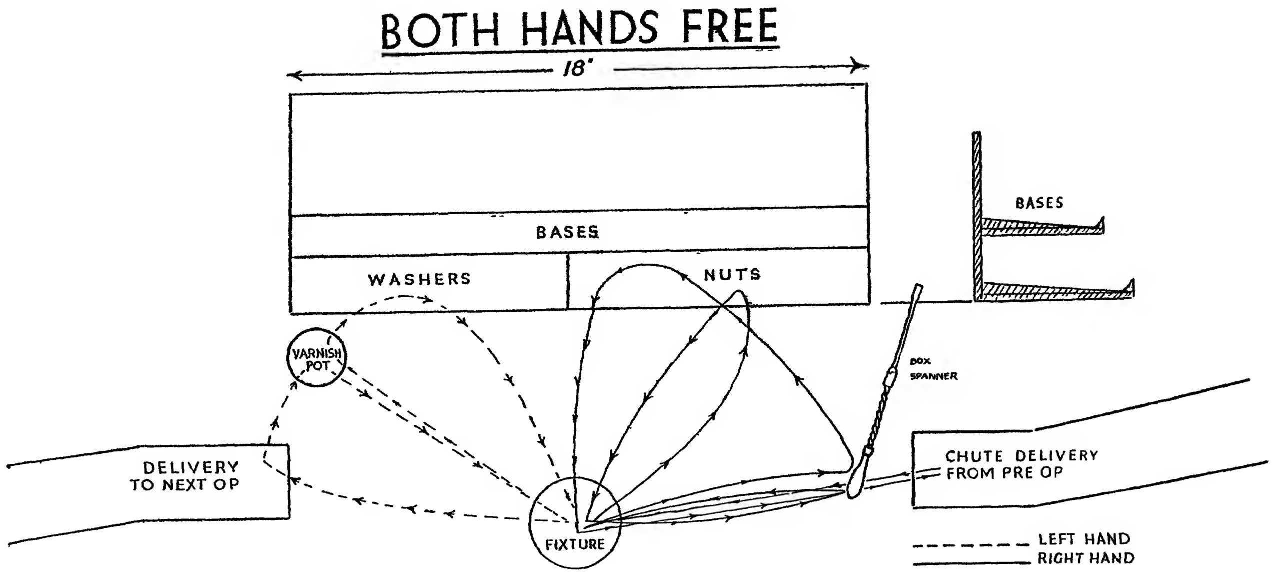


FIG 32

This is a better method because the fixture takes care of the part being assembled and the redistribution of the varnish pot helps to balance the hands It will be observed that the change here is a very minor one, yet it is one that has made a great deal of difference to the study

rhythmic the lay-out of the job the better the results that will accrue.

Before proceeding further, the cost in energy of *each motion* should be investigated.

Firstly, there is the loss of time and rhythm through having to switch the concentration from the job in hand to the new or follow-on job. Concentration switch is the mental *effort* involved every time

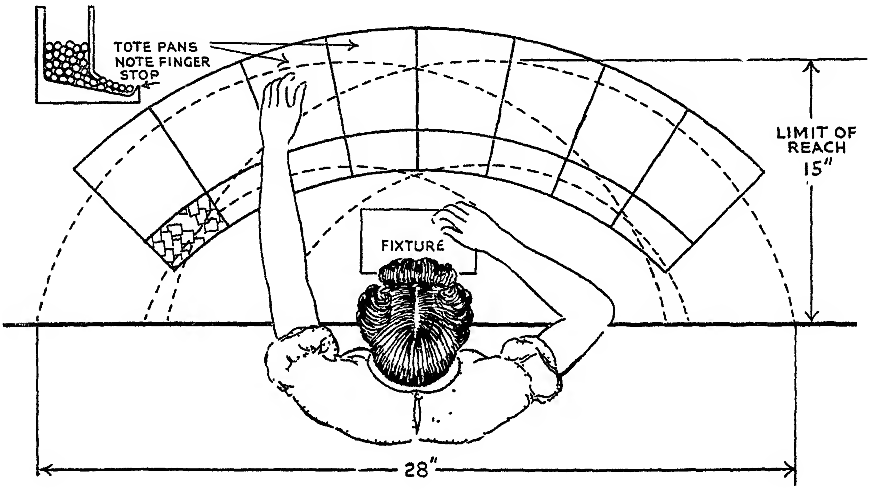


FIG 33

This specimen lay-out has paid particular attention to the ease of accessibility, limitation of reach, balancing of hands, and the easy procuring of parts It will be noted that the tote pan, or supply bin, has a specially designed stop which permits the parts to accumulate without overflowing

an operator needs to focus his attention on a subsequent operation. It can be seen in the simple act of picking up a tool. First, there must be the mental switch from the existing operation, then the mental effort involved in search, locating, grasping, and bringing to hand. All the complex human machinery that goes to control the reflexes of sight and touch, the will that controls the muscles involved in grasping and carrying, the focusing necessary to bring the part to a predetermined location of work site; all of these involve energy dissipation, and the fact that it appears as if these were done with no apparent effort does not mean that they were done *without effort*.

Now, the whole of this takes place every time a single motion is performed and, when it is considered that the average operation

can be so redesigned that an 80 per cent saving in motions can be achieved, it is realized what tremendous savings there are in the study of motion economy.

Whatever the situation of the working area, endeavour should

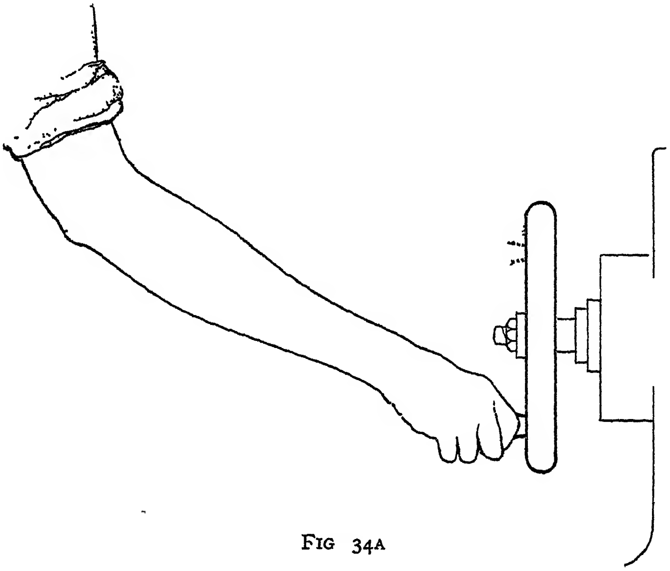


FIG 34A

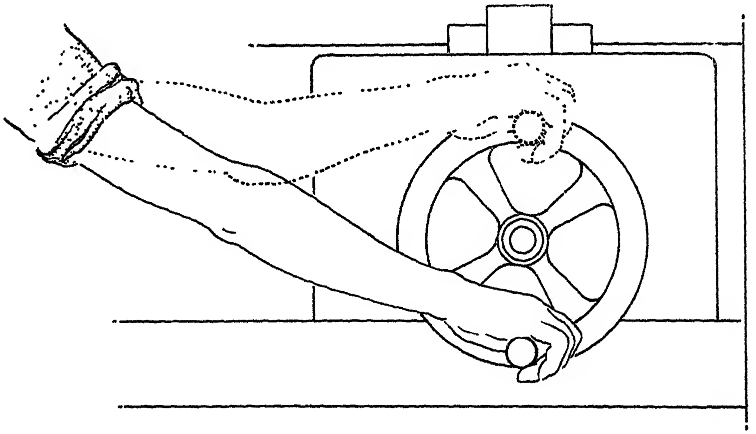


FIG. 34B

Distance of travel is also important in regard to circular motions of the arm and circular motions of the forearm. The difference of travel required is clearly illustrated in the above sketches

be made to place the work on the curve in order that the rhythm previously mentioned shall be more easily introduced.

Here are some other aspects of efficient motion economy.

MAKING USE OF BOTH HANDS. Attention has been drawn to the use of one hand as a vice and its delaying effect on efficient production. The operator should be shown how to use both hands for the purpose of producing parts. Both hands should begin their functions

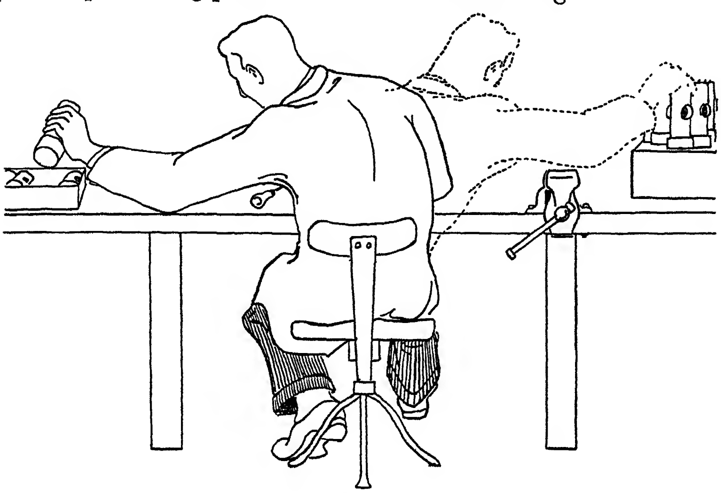


FIG 35

In this sketch it will be seen that extended reach causes unnecessary bending of the operator. In this case the operator is picking up and putting aside, both of which can be taken care of by bench chutes and better bench lay-out.

together where possible, in order to achieve a balance. Both hands should complete their cycle of work together for the same reason.

Where it is impossible to attain perfect balance, only one hand should be idle at a time. For example, in using a Yankee screwdriver or power driver, one hand will almost certainly be used to guide the point of the tool into the slot. Since this hand is not actively engaged in *doing* it, it should be considered idle, and this should be the optimum of idleness for either hand while its fellow is engaged in performing.

When the hands are freed of the encumbrance caused by anchoring (as used as a vice), it does not necessarily follow that exactly twice the amount of work will be performed because of the divided attention factor. This point should be remembered, but nevertheless the saving will still be considerable.

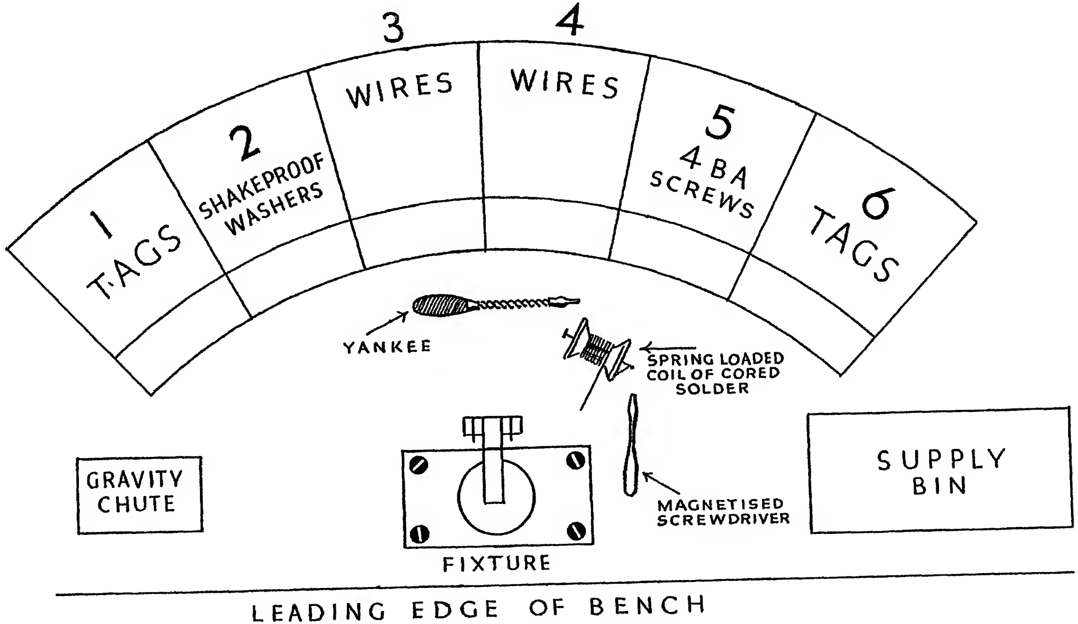


FIG 36

This lay-out has been specially designed to cope with a soldering operation, and it will be observed that the radial type of lay-out lends itself to the practice of efficient motion economy

Arm motions, for complete balance, should be in opposite directions and not in the same direction.

Angles of select, grasp, and locate should, where possible, be confined to the wrist areas, i.e. the work site approximately 12 in. wide, 6 in. deep, and the binning of the parts within reach of the hands while the wrists are resting on the extremes of this area.

Reference to the diagram in Fig. 36 will show how the parts have been prepositioned so that the hands have the minimum of travel and the selection of parts has been built into the rhythm.

USE OF LOWER LIMBS. Full use should be made of the lower limbs. Very often a clamp for holding the assembly can be operated by means of a foot pedal, thus releasing the hands from holding or involving the use of thumbscrews. The foot can also operate a soldering unit, or a spot-welding unit.

The knee can often operate the slide for a gravity chute. This s situated immediately beneath the fixture, and thus permits the completed work to slide to a receptacle without the worker having to move to dispose of it. Naturally the "floor" of the fixture which will be operated by the worker's knee will be spring loaded.

Pre-planning is essential. In a large number of cases the jobs are in the shop before the motion study observer can get round to them, and when this occurs it will be found more difficult to change the habits of the operator. Where possible, the jobs should be motion-studied *before* they go out to the shops.

For this purpose the observer will need to have the drawings in advance so that he can start laying out the job. The blue-prints for the service department should be submitted to the observer to give him an opportunity of seeing if any time-wasting factors have crept into the lay-out.

It is suggested that the provision of a small workshop or laboratory for the observer will enable him to experiment, and this is very necessary because, unless he can experiment in private, the ideal situation will remain obscure due to the fact that he will be unable to give that rapt attention that the job demands.

SUMMARY

Summary of "governors" for efficient motion economy—

1. Careful thought must be given to tool design. It is worth while creating "mock-ups" to determine limit of wasted effort.

2. All lifting should be mechanized (for heavy weights). On bench assembly, lift should be abolished.

3. On assembly work, curved movements have been proved more effective than direct movements, rhythm is thereby engendered.
4. All motions should be reduced to the lowest possible in order to reduce fatigue.
5. A hand should never be used as a vice.
6. If a fixture is used to overcome No. 5, then the fixture should preferably be foot-operated and have quick-operating clamps
7. Observe hand movements, empty "transport" is uneconomic
8. Tools and parts should be prepositioned in order to reduce "concentration switch."
9. Gauges can be permanently fixed, the part travelling to the gauge on its way to the "aside" factor.
10. Bench bins, tote pans, and racks should not be beyond a 15-in. radius from the worksite.
11. Gravity should be used for (*a*) feed, (*b*) putting aside.
12. Gravity-feed containers or chutes should deliver the parts as close as possible to the worksite in order to avoid interrupting the rhythm.
13. Ejectors should be used for finished parts in bench tooling.
14. "Drop" delivery can be operated by lower limb.

All the foregoing points are positive, i.e. they are meant to guide in the planning of the job. When jobs are actually in the shop, however, something more is required, and that is an efficient analysis that aids in the locating of the fault and assists in its elimination.

It is not sufficient to have a job time-studied and then left. If the contract is to run into many thousands, any saving that can be made is going to have an immediately worth-while effect on production, and it is for that reason that *all* jobs necessary for long-term contracts, whether in the shop or not, should be motion-studied.

This must not be taken as endorsing the viewpoint that, if a short run is indicated, motion economy need not be practised, but clearly it is more profitable to concentrate on the operations which are likely to carry on for some months in preference to those which are likely to cease after a few weeks. However, in the case of the latter, common-sense motion economy will prove valuable, but the amount of work called for on a detailed analysis, the amount of labour that will be expended in devising alternative methods, and the cost of redesigning tools if called for, will obviously be unprofitable in the case of the short run.

When it is decided that an operation will repay investigation, the job will have to be carefully studied (much in the same way as that required for an efficient time study) and the elements written up in such a way that the job can be taken away and studied in private.

BREAKING DOWN THE STUDY

Remembering the three fundamentals of all operations—

(*a*) Prepare,
(*b*) Perform,
(*c*) Put aside,

we now break our study down into these three headings Under heading (*a*) we would ask—

1 How do the parts get to the bench (machine)?
2. Are they laid out correctly? In sequence of consumption?
3 What parts are used mostly? Some? Equally?
4. Are parts within reach? Stretching of arm necessary?
5. Is there a fixture? Does operator have to use one hand as a vice?
6. Does operator reach across body? Twist body?
7. Does operator have to stoop to procure?
8. Is seating comfortable? Is light adequate? Too little or too much?

Under heading (*b*) we would expect to find—

1. What tools are used? Can they be improved? Reduced?
2. Is operator working to plan? Whose plan?
3. What handling is involved?
4. Is handling controlled? Systematized? Haphazard?
5 Does each hand perform equal amounts of work?
6. What degree of concentration is required?

And finally, under heading (*c*) we would find—

1. Where is part put?
2. Will drop bin or gravity chute help?
3. Is part inspected by operator? If so, how much? Glance? Gauge?
4. Is job balanced, i e is next operator waiting?

Having broken down the elements, the next step is to analyse each movement of the operator, and one method of doing this is first to write up the operation completely and then break the job down again into left- and right-hand motions. A specimen sheet covering this will be found in Fig. 37. Here it will be seen is a complete analysis of each individual motion, and by comparing the hand movements it can be soon established whether or not the hands are doing a fair share of work. Another point that will be demonstrated is the number of movements necessary to procure. Then this can be followed through to a redesigning of the job in order to reduce the motions to a minimum, bearing in mind the need for inculcating rhythm and balance.

The split-hand watch is used for this analysing of motions. Although this hand watch has been described in Chapter III, it is worth while describing it again, since its use for motion study work is slightly different from that in time study work.

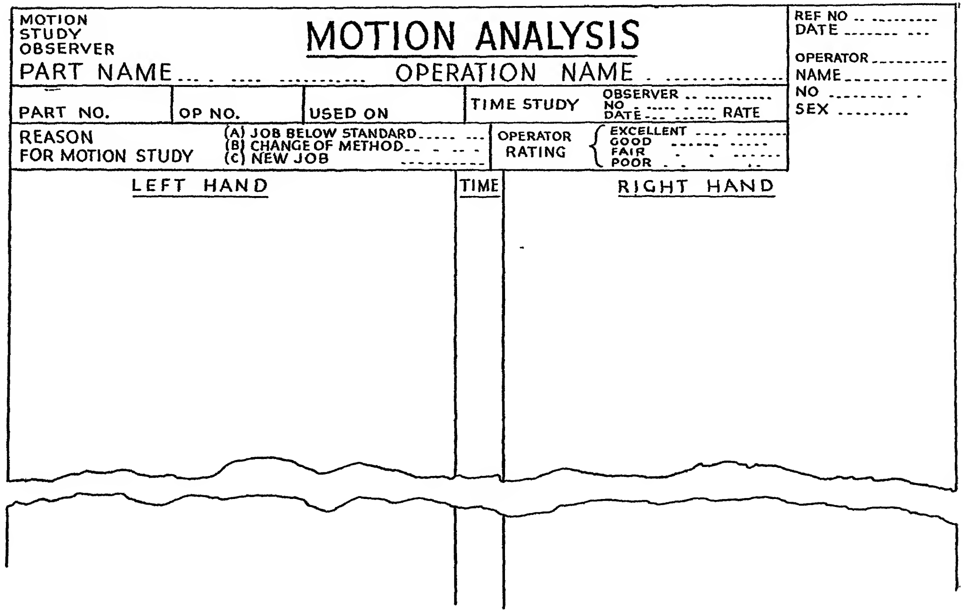

MOTION STUDY OBSERVER
MOTION ANALYSIS
PART NAME
OPERATION NAME
REF NO
DATE
OPERATOR
NAME
NO
SEX
PART NO.
OP NO.
USED ON
TIME STUDY
OBSERVER
NO
DATE
RATE
REASON FOR MOTION STUDY
(A) JOB BELOW STANDARD
(B) CHANGE OF METHOD
(C) NEW JOB
OPERATOR RATING
EXCELLENT
GOOD
FAIR
POOR
LEFT HAND
TIME
RIGHT HAND

FIG 37

This Motion Analysis Chart is used by first writing up the descriptions and then, as the operations are performed, recording the time taken Provision for the operator rating is not against the times recorded, but in a separate section at the top This is because the concentration factor on the part of the observer is so great that he must rely on an overall operator-efficiency rating, rather than an individual element rating

The reader will realize that in time study each individual element is rated; in motion study work this is too difficult to do, because the whole of the observer's attention must be concentrated on analysing motions—not speed. The latter is more properly within the scope of the time study engineer.

Speed, however, plays an important part, for this reason. While practice and natural dexterity will give an illusion of efficiency, nevertheless the speed is an accomplished fact It does not matter whether the job is being done properly or not (according to motion economy standards of course!); speed is the measure But where the motion study observer makes changes, the actual speed of the operation will naturally be affected, due to the absence of *habit*. Once, however, the habit has been established, if the motion study observer has done his job properly, the job should prove more rapid in execution than the original.

The watch, then, is used to record the actual time being taken over each motion, and the rating can only be left until the last. It is better to avoid rating from the speed point of view; it is far better to rate the operator according to his overall efficiency and not according to his performance of given motions

USING THE WATCH

The watch (see Fig 3) is divided into seconds; it is not recommended that a decimal face be used, since we are not concerned with the computations involved, but are interested only in performance. There are two hands, both operated by the main knob at the top of the watch. The oval-shaped depressor at the top left separates the hands by stopping one, the other continuing until stopped by the main knob. The stopped hand can be released by the side depressor by pressing once, whereupon it immediately joins the second hand wherever it may be.

To read the watch (using the inner dial), seconds recording, the watch is started when the operation commences, the finger being held poised over the top left depressor as the operation is finished or the motion completed. The second hand is stopped while the first hand continues to record The reading is taken from the stopped hand which is then released to join the first; thus a continuity of readings takes place and at the same time accurate cycle readings can be obtained.

This is the continuous reading method, the difference between any two readings being the time taken.

Reference to the drawing (Fig. 37) will show how the readings

are recorded. It should be appreciated that there is a great deal of work attached to this form of study, and it is not one to be lightly undertaken by the inexpert.

Having thus obtained the data, it is easy to see which hands are overburdened and which are idle and for how long. A sketch should be made of the lay-out in order that the reason for delays, idleness, or bad balancing of movement may be more easily discernible.

ACHIEVING BALANCE (PHYSICAL)

Very often it will be observed that operators perform unnecessary movements of the arms, even of the feet, to compensate for a poor distribution of the labour. A sample of this can be seen in the operation of swinging a fly press. The operator will use the left hand to feed the part to the jib as the right hand pulls round the fly handle, so that the left hand will be found to be held quite rigidly across the front of the body but not touching the body at all. Frequent observation seems to indicate that this is an instinctive balance-impelled factor.

Another observed case involved whipping, with a piece of waxed string, the end of a rubber cable. The operator in this case, after seizing the dormant end of the string with a pair of flat pliers, pulled twice and then for no apparent reason finished off with at least three waves of the pliers. The extraordinary thing about it was that the operator *knew* what she was doing and, when questioned, confessed that there was no purpose served but, even then, did not alter the habit.

Both of these cases appear to be due to lack of balance; the operator subconsciously adopting a pose or extra motion which helps to relieve the strain.

In the case of the fly-press operator, the raising of the working height by means of a dais helped to eliminate that unbalanced feeling, the original cause being that the right hand was higher placed than the left, thus altering the centre line of the body itself, and therefore the weight distribution.

In the case of the second operator, the aimless motion of the pliers was due to reaction; so much effort had been put into pulling the dormant end of the string through the whipping that the wrist was tending to become cramped and the muscles suffering from strain. This was overcome by increasing the size of the pliers from 8 in. to 10 in. and grinding down the nose of the pliers to increase their sensitivity of grip.

One of the reasons for the desirability of both hands being

occupied at the same time is this question of maintaining balance. Clearly if only one hand is occupied then one side of the body is more used than the other, with the result that fatigue is greater; certainly it is more apparent.

Unless balance is achieved, a reduction in working efficiency must always be expected, therefore a good deal of attention and

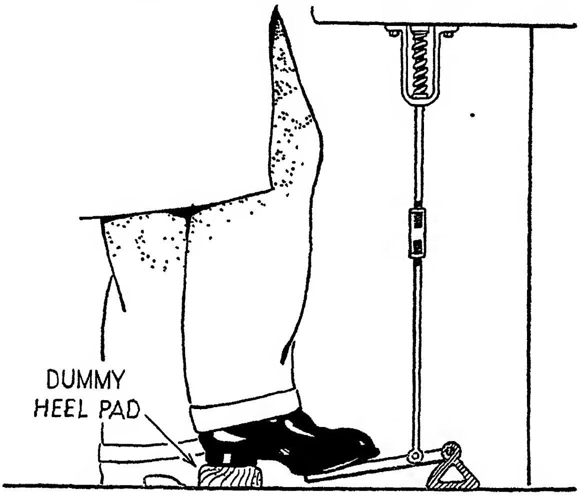


FIG. 38

The provision of a dummy heel pad materially assists in reduction of fatigue There is another factor involved and this is that it enables the operator's foot to be always prepositioned.

experiment must be paid to it. The achievement of balance should, where possible, be of a positive nature. For instance, to put a "grip" handle on the machine for the left hand to grasp merely to achieve balance is a negative solution Far better for the left hand to be seeking the new part or taking away a finished part, while the right hand is engaged in operation, than to have it idle. The incorporation of the left-hand feed and removal is positive balance; the provision of a grip is negative. But both achieve the same ends.

If the worker is using a foot-operated pedal, it is very necessary to ensure that either (*a*) the operator is sitting down, or (*b*) the operator has some support for the body. This is for two reasons. In (*a*) the operator will be able to concentrate on the job without having the attention distracted by reason of having to feel for the pedal. In this connexion it is advisable to have a dummy heel pad fitted so that the foot can always be in the proper position (see

Fig. 38). In (*b*) if no support is given, the shifting of the weight from one foot to the other throughout the day imposes an unnecessary fatigue; and further, if the weight of the body has to be supported by one foot while the other is engaged in pressing the pedal, then, as the fatigue increases, more and more weight will be transferred from the supporting foot to the pedal, thus imposing a mechanical strain upon the machine.

Balance is also brought into play in the use of hand tools. The handling of a hammer is a good illustration. If the hammer is held near its head, greater force has to be exerted to give the same result as if it were held near the heel. Some schools of thought aver that the wrist motion in tapping with a hammer is the better one; it is the author's experience that the forearm motion, involving the use of the elbow as a hinge rather than the wrist, is less tiring. Naturally, if the work is very delicate, requiring a great deal of control, this is a different story, but, in general, evidence seems to point to the use of the forearm which gives a better *balance*.

Another condition which gives rise to ill-balance is on presses; it will often be seen that the operator will be sitting at the machine, feeding with the right hand. This means that, since the press is equipped with an automatic ejector, the left hand is idle. There is no reason why *two* supply bins should not be used and the feeding made alternate. Thus while one part is being formed and ejected, the other hand would be selecting, grasping, and bringing up the second part These machines are usually treadle-controlled and always have a safety cage, so that each hand can be quite usefully employed. The all-important rhythm factor too is given full rein.

This lack of balance is also demonstrated on the various vertical marking machines. The long handle to be pulled backwards and forwards imposes a great strain on one side of the operator and does not permit much variation in the use of the opposite side. Once the left hand has located the part in the slide, there is nothing more to be done by the left hand until the part has reached the end of the roller, where it is extracted and dropped into a bin In a case like this, where the problem is well-nigh insoluble, it would be as well seriously to consider making the job a short-shift one, i.e transferring the job to another operator after about two hours' work in order that the fatigue will not accumulate.

Another job that neglects balance will be found in spot welding. In this case the usual set-up involves the use of the right hand only, apart from the picking up of the part. Because the welder is pedal-operated, this means that the right hand is solely engaged in holding

while the left hand is completely idle This can be overcome by rearranging as the accompanying sketch (Fig 39) demonstrates. Here the alternative method of feeding has been incorporated with a speeding up of the operation, together with the achievement of balance. It will be seen that this aids balanced operation in every sense of the word The pick-up and the disposal is so organized that each hand has exactly the same amount of work to perform.

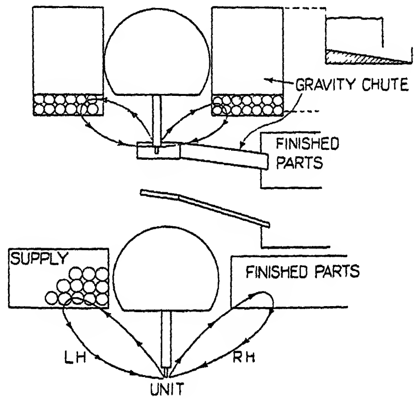


FIG 39 DIAGRAMMATIC LAY-OUT FOR SPOT-WELDING OPERATIONS

Excessive hand travel and effort shown in the lower diagram is largely reduced (above) by the use of gravity-fed chutes for supply and disposal of parts.

(*By courtesy of "Aircraft Production"*)

JIGS AND FIXTURES

The use of jigs and fixtures as an aid to efficient motion economy is of considerable importance, but important also is the relationship the cost bears to the saving. For example, a saving of 10 per cent in labour on a job in constant use justifies a more searching analysis and application of the toolmaker's time than a jig or fixture which shows a 90 per cent saving on small batches coming through probably only once or twice in a year.

A jig is used to hold the work around or in the path of a tool, a fixture is a work-holding device usually fixed to a bench or machine table. Naturally, the greater the precision needed on the jig or fixture, the greater the manufacturing cost; and since the manufacturing cost of jigs and fixtures is of no less importance than the cost of production labour, the relative merits will have to be the subject of inquiry before it is decided to plan a work-aid.

The following questions should be satisfactorily answered before a jig or fixture is suggested as an aid to increasing production—

1. Length of run of contract?
2. Cost of fixture or jig?
3. How many pieces to be made before cost of tool can be recovered from saving?
4. What profit can be expected from fixture or jig, bearing in mind the need for replacement if tolerances are close or tool wear high?

5. Can jig or fixture be designed for alternative parts of similar size and shape?

6. What maintenance will be required?

7. What will be its life? Has experience shown a short life in jigs and fixtures due to obsolescence?

When these points have been considered, it will be found that a definite pointer will be given to the value of the work-aid.

Fundamentals of Jig and Fixture Design. Naturally, the correct dimensions will have to be obtained before any work can be put in hand. It follows that these dimensions *must* allow for sliding or driving fits in order that energy dissipation will not defeat the purpose for which the work-aid is designed

Whatever the system of gauging or the standard of inspection, this should be used as a guide; where parts are to be mated there must be a constant point of location, otherwise there is a risk of extremes of tolerances, rendering the job out of true. Clamping in fixture must be so designed that both hands are free of the "positioning" or "holding" elements. Clamps should be spring (or air) loaded or, alternatively, cam-operated, and easy to handle. Attention must be paid to the "pick-up" or "selection" point in order that operators do not have to change hands to load.

Needless to say, fixtures should be interchangeable on machine tools.

Fixtures and jigs (and for that matter, all tools) should carry an identification number, so that easy reference can be made.

All work should be capable of being located accurately, positively, and without loss of time or the introduction of fumbling.

The job must be safe.

CHAPTER XII

LIGHTING AND TRANSPORT AS WASTE FACTORS

LIGHTING

MENTION has already been made of this in relation to the specific jobs, but the need for a comprehensive review makes the inclusion of this section a necessity.

The art of looking is a distinctly different function from that of seeing In the former, it is deliberate focusing of the sight and the attention on an object or in search of an object, in the latter it is purely a reflex action—one can see without looking but it is impossible to look without seeing.

Now, operators look, or, putting it another way, seek to find. Their job, whatever it is, is always prefaced by the act of seeking. Therefore, whatever aid can be given to this act must have a beneficial effect on the general efficiency and a favourable reaction upon production.

Lighting naturally plays an important rôle in this act and thus needs to be of the highest efficiency itself. The amount of light available is not necessarily the criterion of the best illumination. A large lamp in a large area is of less value to the operator than a small lamp in a small area, *if that area composes the worksite.*

Another point to observe is that the relative attraction of the object being looked at must also bear comparison with the relative attraction of other objects in the same focal plane. The expression of this relationship can be demonstrated by an example. Suppose there are several silver balls on a table, all close together; if a bright light is suspended immediately above, the result will be a dazzling array of silver balls. Therefore it will be difficult to focus on one particular ball, due to the conflicting attraction of the pile as a whole.

To carry the analogy further. If there was a very dim light over the group of balls and instead of being silver they were painted matt black, it would follow that instead of there being a dazzling array, there would be a confused dark mass, only the general outline being relatively clear, due to the demarcation of solids and space.

Therefore the use of direct lighting with, so far as possible, an exclusion of divergent attractions, must be the aim of the motion economist.

To this end, the refraction of the surrounding areas to the worksite is worthy of attention. If the surrounds can be painted a

contrasting colour to the mass, this will help to direct the vision to that work site. Not only this, but by paying due heed to the surrounding area it is possible to reduce the amount of light necessary for the efficient task performance

The painting should be done in pastel shades and should not embrace too wide an area, or the localizing of the concentration will be defeated

ANALYSING THE LIGHTING

The following gives a guide to the type of question that should be asked when analysing the lighting of the shop/job.

(*a*) Is the lighting adequate?
(*b*) Will glare or dazzle points cause distraction or discomfort?
(*c*) Are shadows on the work in hand being caused by—

(1) Movable obstructions?
(2) Immovable obstructions?

(*d*) Are lamps so situated that the actual light rays strike the operator's eyes?
(*e*) Will individual lighting improve the job?
(*f*) Is lighting master-controlled, i.e. all or none?
(*g*) If the lamp is near the operator, will the heat discharge cause fatigue?

(*a*) Adequate lighting means, of course, sufficient illumination so that the job or function may be performed satisfactorily and without eye strain. This brings in another condition, that is the state of affairs where there can be too much light, thus causing eye strain. This is a different condition from (*b*) because in the case of too much light, although there may be no direct glare, the amount of excessive light causes the muscles controlling the pupil to be in a constant state of tension due to contraction. Thus fatigue is engendered.

The right light for the right job can be interpreted in a variety of ways. Quite obviously some jobs will require a higher foot-candle than others, e.g. if working on a machine the lighting, although important, is not so demanding of sight concentration in the selection and grading of small mica parts

(*b*) Attention should be paid to glare and/or dazzle points. Glare will cause eye strain in much the same way as described above, while dazzle points will cause a diversion of concentration and a redirection of light rays into the eyes. These two factors can cause

as much strain as an insufficient light which makes the operator peer and slows down output. In Fig. 40 will be seen an example of a dazzle point, and it can be overcome by the substitution of fluorescent lamps.

(*c*) Shadows cast upon the work in hand will make any increase in the actual lighting ratio valueless, the removal of the cause of

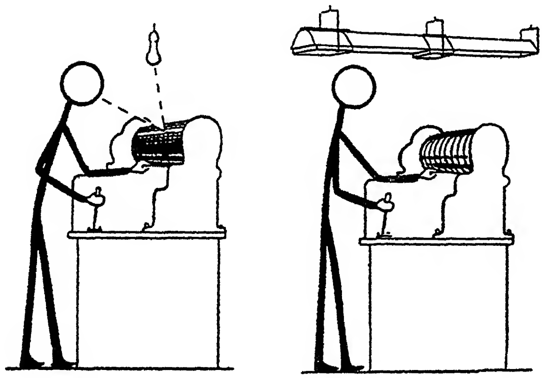


FIG 40
The location of a single light over the worksite often gives rise to dazzle points The substitution of fluorescent lighting for ordinary lighting will do much to eliminate this troublesome and irritating factor
(*By courtesy of the B T -H Co Ltd*)

the shadows is an obvious solution, and where this can be accomplished it should be done. However, there are occasions when the shadow is caused by structural design or some other immovable obstruction. Lighting can be so *designed* that it can overcome shadow-forming substance. An example of this can be seen in Fig. 41. By the introduction of the fluorescent type of lighting the shadow entirely disappears.

(*d*) In Fig. 42 will be seen the difference between two types of lighting. In one type the light rays are not focused on the work, the lighting is of a general illuminating character; the light is so situated that it has to play on a general area with the result that it strikes directly into the eyes of the operator. But reference to the second diagram shows relatively the same positioning, but with the added advantage that the lighting is not directly affecting the operator.

(*e*) Individual lighting is an ideal. In a large number of cases, however, not only is it undesirable from the point of view of overloading the current supply, but also there is the question of economy to be considered.

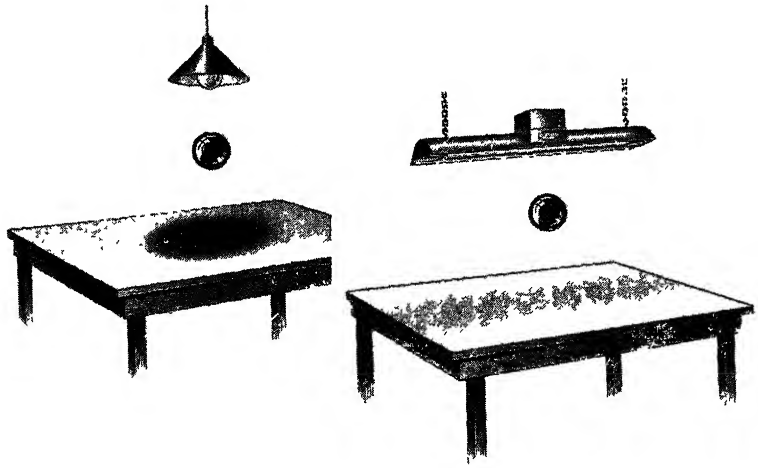


FIG 41

Here it will be seen how completely shadow can be eliminated by fluorescent lighting This is an important point to consider where assembly operations are being performed and very small parts are involved

(*By courtesy of the B T -H Co Ltd*)

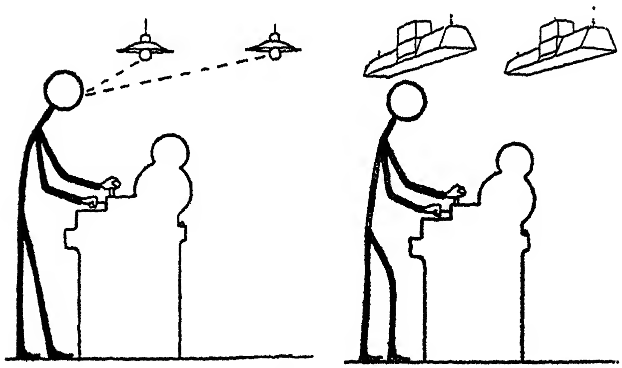


FIG 42

Here is a clear illustration of light being distracting The illustration demonstrates to the full the advantages that come from a close study of this important point

(*By courtesy of the B.T -H Co Ltd.*)

(*f*) Where individual lighting is called for, or even where there are group lights, the question of control naturally arises. In the case of the machining needs, where the illumination is controlled by the operator, this point does not arise. But where lighting is of a more general nature, for instance, one light to every five or six operators, the question of control can be a perplexing one. Very often there is a master switch for the whole shop or battery of lamps; therefore if only one operator wants a light due perhaps to the position of the machine in relation to the daylight, then obviously it is wasteful to switch on *all* the lights, yet not to put on the light for the one operator is to invite strain and faulty work. This point bears investigation.

(*g*) Another case that requires careful thought is where there is a powerful lamp situated near an operator. Often the heat discharge will cause discomfort, and it is advisable to consider the removal of either the lamp or the machine from the sphere of the lamp's influence. This heat radiation is a matter of grave concern where there is a suspended lamp near an operator who has to concentrate on a job demanding care Some inspection jobs call for this condition, and in these cases it is worth while considering indirect reflectors, which, although transmitting light, nevertheless aid materially in the reduction of heat radiation.

"Daylight" Lamps. Where there is to be artificial light all day it is a worthy and justified expense to change over to "daylight" lamps. The working in artificial light predisposes towards extreme irritability and consequent fatigue accompanied by rejects and poor workmanship. Therefore, if artificial lighting is to be continuous, then "daylight" lamps will do much to mitigate its evils.

TRANSPORT

The other ancillary to effective practising of motion economy is transport. As discussed in the previous chapter, trucking, handling, and other forms of internal transport represent a very large proportion of the "overheads." One big drawback to a large service staff is the labour turnover. In much the same way that direct workers, by having a large turnover, cost the firm money because of the need for retraining, so the service departments, for the same reason, involve quite considerable sums.

An analysis of the costing sheet will reveal the number of labourers engaged solely on transportation, that is shifting material from the unloading bay to the stores, from the stores to the machine, from machine to machine, from machine shop to stores, from stores

to assembly plants and to inspection bays, and from there to dispatch. Right throughout the factory man-hours are tied up with sheer unproductive labour, dissipation of energy that yields no return and contributes nothing tangible to production quota.

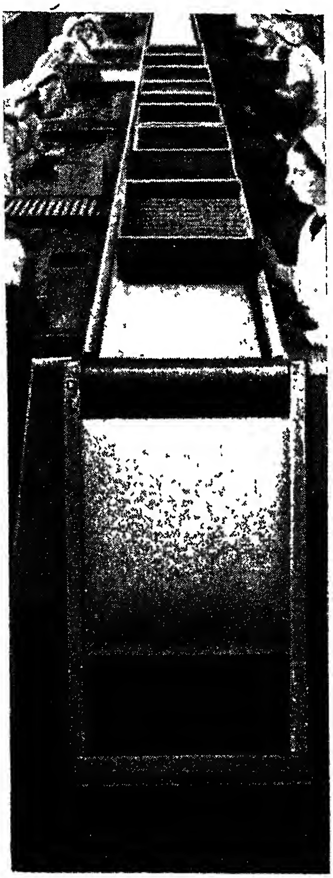


FIG. 43
The provision of a belt conveyor does a great deal to improve production, and it is obvious that the greatest saving comes from the complete elimination of trucking.
(*By courtesy of Sovex Ltd*)

The wages alone are not a guide to the total waste. There is the labour involved in computing those wages, the supervision necessary to ensure that the material arrives at the right place at the right time, and, above all, the constant risk of human fallibility.

This is why the motion economist will pay a great deal of attention to the provision of conveyors and to the substitution of labour for trucking by mechanical means of transport.

There is no doubt that in the factory design of the future, the mechanics of transport will be taken care of, but for the time being under existing conditions improvisation to a certain extent will have to be considered if the full benefit from the motion economy of the factory is to be extracted.

It should be the constant care of the motion study observer to eliminate the human factor in transport, and a study of the subject will suggest many diverse ways by which this can be accomplished.

Broadly speaking, mechanical transport falls into four groups—

(*a*) Conveyors.
(*b*) Chutes.
(*c*) Elevators.
(*d*) Mechanical trucking.

BELT CONVEYORS

Where there are large-scale assemblies the belt conveyor is to be recommended (see Fig. 43); the provision of this cuts out the handling of parts between operator and operator, and permits the

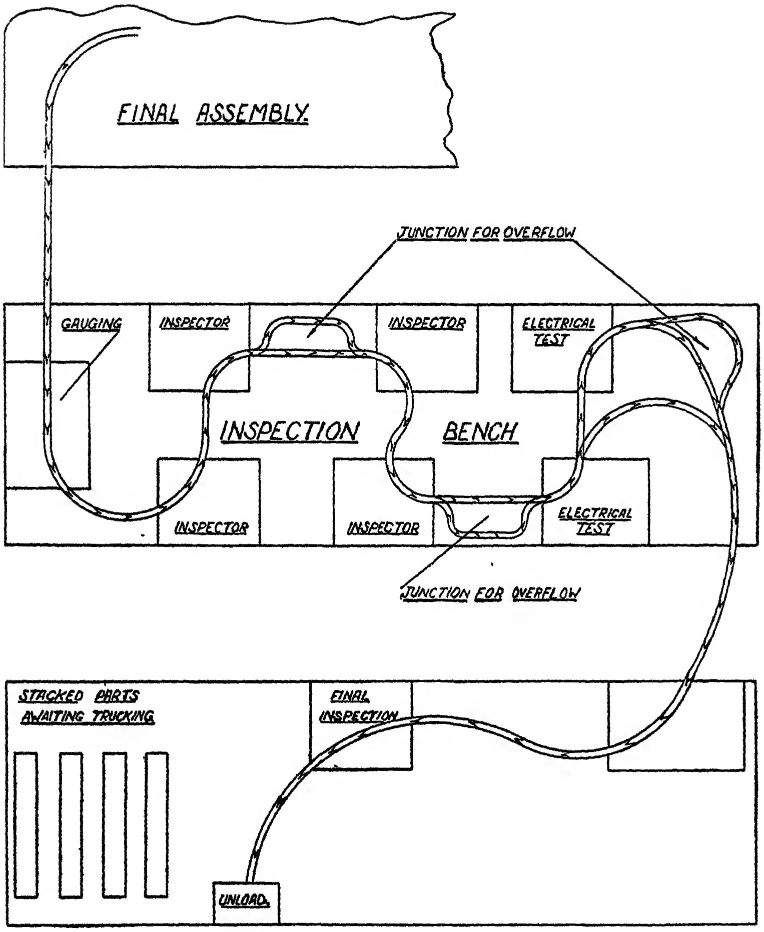


FIG 44

Mechanical conveyors are particularly suited to inspection departments Where inspectorate is immobile then, as the parts have to travel to this section, it is obviously desirable that they should travel mechanically. The diagram illustrates how overflows can be arranged so that there is never any fear of the inspectors passing bad work due to the speed of the conveyor.

development of a flow line to be performed with greater accuracy. Another point in its favour is that the constant speed can be maintained, thus reducing the tendency for a number of operators to slacken off to the detriment of the line as a whole. One of its disadvantages is that the speed of the belt will have to be adjusted to allow for compensated relaxation. This, however, lends itself to the provision of fixed relaxation periods every hour, which is the ideal formula. The assembly stations should be fixed on alternate sides of the belt where possible in order that the greatest advantage may be taken of bench space. Further, this alternation of bays allows the by-passing of "suspects" to take place (See Fig. 44.)

The slat conveyor is based on a similar scheme to the above with the difference that it is more useful for heavier assemblies or parts It can be placed at floor level, which is an advantage since there is no gangway obstruction. This type of conveyor is sufficiently robust to take almost any strain, and where it is necessary for traffic to cross over it, this can be done in perfect safety, due to the low speed of the conveyor. One particular advantage in this type of conveyor for the checking department is that it can be arranged to incorporate a weighing machine; thus one more economy of motion can be achieved.

The slat type of conveyor can be made to travel almost anywhere; for instance, it can carry a load along a floor and then rise to bench level to facilitate inspection of packing. Its use in the machine shop for the trucking of heavy castings is obvious. The amount of time it will save and the labour it can free would make the introduction of this an economical proposition.

CHUTES

There are several types of chutes. There is the bench gravity chute, transferring parts from operator to operator, from operator to inspection, or from operator to a gravity bin situated on the floor. The advantage of this type of chute lies in the fact that it takes no power to operate, involving as it does one of the oldest of the physical laws.

There are other types of chutes: those connecting floors, those delivering parts to machines, and the type that has one main feed with a selective device that separates the parts to be delivered for different sections. This type is based on the size or weight selecting process and is extremely valuable for the organization making a variety of parts going to a common pool, such as stores. This type of chute is usually radial or spiral and occupies little space. The fact

that it is circular allows the law of centrifugal force to operate, thus preventing the heavy and bulky parts from attaining too great a descending speed, a point worth considering when the parts are liable to damage.

ELEVATORS

Elevators are particularly useful where parts have to travel in an upward direction. Mention has been made of lifts and the fact that, due to the "transport empty" factor, a considerable wastage occurs. The use of elevators, which after all can only work by elevating, eliminates the use of these whilst empty. They can then be used for a variety of purposes, and the most applicable to a factory is in the passage of machined parts from the machine shop (usually on the ground floor) to the assembly shops, which are invariably situated upstairs. The elevator system is usually based on the "grasp" method, i.e. the part is firmly held until it reaches its destination. Now this is a great improvement over the trucking system involving the use of a lift, because the human element is cut out completely, thus minimizing the risk of damage due to bad handling.

TRUCKS

Where there is difficulty in employing any form of mechanical conveyor, the use of trucks is the only solution. But even these can be mechanized. It is a reflection on our present-day speed of development to be still tied to the use of manually-propelled trucks when one girl can release several men by the adoption of electric trucks.

CHAPTER XIII

TRAINING OF OPERATORS

ONE of the factors affecting operator efficiency must necessarily be the reaction of the operator, and this point is one worthy of close study, because if the operator is non-co-operative the whole point of motion economy is lost. Co-operation can be gained the "hard" way, that is, by using authority as an adjunct for the implementation of motion economy rules of training, but, naturally, it is much better to lead than to drive, and the motion study observer will do well to consider this point.

Another factor arising out of the foregoing is that operators are very often square pegs in round holes, and while they may be performing the task that has been set them reasonably efficiently, nevertheless maximum production cannot be obtained.

Some organizations naturally look askance at any form of operator selection and/or training, because it is argued that the time spent in training an operator must bear a ratio to the potential "life" of the operator. This point is convincing only when it refers specifically to female operators who will in due time get married and leave the firm. It does not apply to operators who, by reason of the interest they have in the firm, can develop into permanent employees of either sex. The labour turnover of a firm is dependent upon the conditions under which the operators work, and as this is self-evident it is equally obvious that if the conditions can be so made that the operators *like* working in a particular organization, and that there is opportunity for promotion, and, in addition, some interest in the work in hand, then obviously labour turnover can be reduced. Therefore, if we can assume that the labour turnover is 10 per cent of an organization, and that the average female "life" is five years, then on this count alone the provision of operator selection tests and/or training becomes a worth-while proposition.

Operator selection tests will not throw up the operator's particular skill in any one branch of industry, but it will demonstrate the operator's suitability or otherwise for particular spheres. Tests can be broadly divided into two—

(*a*) Vocational selection.

(*b*) Vocational guidance.

Under (*a*) a test can be applied to establish the operator's

inherent aptitude for certain tasks, and under (*b*) a test can be applied to discover what qualifications are required in any one person to fulfil a certain function.

VOCATIONAL SELECTION

In (*a*) the tests will not reveal whether a person is likely to make a good capstan operator as against a milling operator, but it will reveal whether the person submitting himself to the test is likely to make good at operations involving the use of machinery, or if he is to be set to operations involving manual dexterity. The test will reveal if the candidate has a ready appreciation, is quick-witted, and is able to seize opportunities.

These tests are carried out either by or in conjunction with the National Institute of Industrial Psychology, and organizations can arrange to have their own observers trained in order that these tests can then be applied on the factory premises The application of these tests then leads us a stage further in our search for maximum production, namely, the training of operators; and it is on this question that there are some sharply-divided schools of thought.

There are many ways of acquiring knowledge of a job—

(*a*) The operator can be left to his own devices and "pick up" the threads of the job by "trial and error."

(*b*) The operator can be seconded to a more experienced operator and be shown by demonstration how the job should be performed.

(*c*) The operator can be properly trained by skilled disseminators of knowledge

(*d*) The operator can be assumed to have a basic knowledge of the job (from previous experience) and be left to work out his own methods.

It will be clearly seen that all of the above points have one inherent weakness, and that is that only sufficient information will be imparted to perform the job in hand, and no record will be kept of the operator's progress through the passage of time; thus a great deal of potential administrators or supervisors will be missed through lack of knowledge on the part of management and scope for possible promotion. It is to this end that all organizations of reasonable size should have a training department under the control of somebody who is skilled in operator selection, and has mastered the art of teaching. Naturally, the size of the training department will vary according to the size of the factory or organization. In the case of a very small concern, the training department supervisor can probably efficiently perform the task as a spare-time activity.

In the case of larger organizations, the training department staff will probably need to be augmented to deal with the various record-keeping and progress reports that will accrue, and the utilization of which will permit a broad picture of the average efficiency of the factory personnel to be drawn. The training department's main function is, of course, to teach operators their particular functions and, it should be noted, to teach them well, to instil into them the elements of labour-saving and motion economy ideas in order that they can, with guidance, perform their own tasks more efficiently.

Another important aspect of this question of training is the fact that the training will help to reduce the time lag between unskilled labour and skilled labour. These terms, of course, are purely relative to the job, and are not relative to the established customs and interpretations of "skilled" and "semi-skilled." Clearly, it is to any firm's benefit if the "passenger" period of an operator's "life" can be reduced, and a training department will, of course, materially assist in this.

Another important part that the training department will play is the progressing of operators, that is, the recommending to supervision that certain operators should be watched because they have in them inherent qualities of leadership and they will probably be worthy of promotion in due course.

When organizations can afford to have a large training department with its staff engaged full time, lags between intake of labour can usually be accounted for by passing operators who are on idle time to the training department for either—

(*a*) Retraining; or

(*b*) Training in a new branch of the work.

One advantage of a training department is that opeartors more quickly settle down. If, on joining a firm, operators are projected directly into the shops, they spend some considerable part of their early life in the factory getting used to conditions, and they also become a distraction to other operators through their quest for knowledge. Operators who first pass through the training department (even if they are fully trained in their particular job) can be given a comprehensive grasp of the firm's activities in a very short time. The training department will be particularly useful to the time study and motion study departments by virtue of the fact that there will always be a supply of labour available so that experiments can be made. Further, by introducing the new employee to the methods of wage payments, many difficulties are removed and

misconceptions avoided. The training department personnel can also be of great assistance to the methods department, because they will be in a very good position to "spotlight" difficulties in production methods that might otherwise be missed

TRAINING DEPARTMENT FUNCTIONS

The functions of a training department, therefore, can be broken down into the following sections—

(*a*) Determination of the suitability of the candidate for a post, based on—

(1) Previous experience.
(2) Knowledge.
(3) Adaptability. (Selection tests.)
(4) Temperament. (Selection tests.)
(5) Expected remuneration.

(*b*) Grading of employees according to definite wage-groups and the arranging for upgrading where indicated.

(*c*) Selection and training of operators for special jobs (also in connexion with (*b*)).

(*d*) Retraining of operators found unsuitable for the posts for which they were originally engaged

(*e*) Training of operators in work methods.

(*f*) Introduction of operators to works organization and conditions.

The running of a training department is not one to be lightly undertaken. If the results are to be worth while, the training department must be well run. There must be no half-way measures, because if the organization of this department is sketchy, then the results will just simply be not worth while.

Even if the limitations imposed on it are economic, i.e. the size of the firm does not justify a large training department, nevertheless considerable thought and attention must be given to the department's scope and responsibilities.

Fundamentally, the department's object is to teach—nothing less. It must be used to the full, and the administrative side must never be allowed to interfere with its functional objectiveness. The training of operators will be preceded by an introduction to that part of works policy that affects the operator.

Then should come the teaching. It is assumed that at the preliminary interview or by a subsequent test the operator will have been told the department in which he is to work. This classifies

the operator and assists the training department in determining into what section the tuition is to fall.

This should be carefully considered. The operator should first be taken into the department or workshop, there to be given an idea of the conditions under which he will be working. This helps to create the atmosphere, and then during the training period there will be little fear that the operator will gain a false conception, due to the inevitable artificiality of the training department as a substitute for the real thing.

If the operator is on work in the machine shop, he will be taught the use of gauges, how to read verniers and micrometers (even though gap-gauges will probably be supplied), given a short talk on metals and the need for conserving tool life. Following this, practical training will take place on the machines to which the operator is to be assigned.

If the operator comes to the training department as "skilled," that is, has had previous experience in machining, it is to be recommended that he still undergoes this training, if only from the point of view that opportunity will be afforded to observe the class of work the operator produces. Further, this training will enable the instructors to discover any faults due to bad habits which can be remedied. It may be that the operator, because of his previous experience, turns out a very good job, but runs the feeds too fast, thus causing excessive wear. It may be that, even if the work is up to standard, through ignorance bad motions or excessive handling time are evident. The opportunity thus presented for correcting these tendencies will more than repay time spent in being passed through the training department.

Opportunity should also be taken to train the operator in the correct motions, and to impart such information that will enable the operator himself to develop his own technique. This is important. because if operators have been trained in the common-sense application of economies of motion, when the time comes for them to be advised in the shops, their minds will be more receptive, and they will have a more ready appreciation of the reasons behind the advice. This will be a great help to the time and motion study departments, because operators will not have to be "sold" on the idea of saving time, material, and energy Therefore, it follows that the training staff must be, if not experts, at least fully conversant with the fundamentals of motion economy, and if it is proposed to train one's own training staff, then the motion study department will be able to provide a considerable degree of assistance.

A WORKS TRAINING SCHEME

There should be a regular programme devised for the training of operators and a syllabus should be prepared which will cover two distinct phases of training, viz.—

1. Works policy.
2. Specific needs of the department concerned.

Here is a sample of a works training scheme.

First Day

a.m.	
8.0–8.30	Talk by the personnel manager, introducing the need for standardized training, pointing out the fact that records of progress are kept and future supervisors are indicated early in the training.
8.30–9 0	Explanation of hours, pay rates, and breaks
9.0–10 0	Works policy regarding sickness, holidays, insurance, special rules, welfare, etc
10.0–10 15	Break.
10.15–11.30	Facilities. Canteen, sports club. Medical section. Safety. Transport. Test (special or selective).
11.30–12.0	Clock cards and clocking, working out hourly rate, deductions, etc.
p.m.	
12.0–1.30	Lunch break.
1.30–2.30	Bonus system, payment by results, computing earnings, appeals, etc.
2.30–3 0	Tour of shop, introduction to future supervision.
3.0–4 0	Practical work, simple introduction to types of work.
4.0–4.15	Break
4.15–5.0	Inspection standards, care of gauges, use of gauges.
5.0–6.30	More practical work

Second Day

a.m.	
8.0–9 0	Easy methods of working, an introduction to labour-saving.
9.0–10.0	More practical work.
10.0–10.15	Break.
10 15–11.30	Tour of the factory, following the parts being made in the training department through to the finished product. Pointing out the importance of accuracy
11.30–12.0	Practical work
p.m.	
12.0–1.30	Lunch break
1.30–2.30	Practical work.
2.30–3.30	Demonstration of speed by experienced operator.
3.30–4.0	"Any questions."
4.0–4.15	Break.
4.15–6.30	Practical work.

CHAPTER XIV

MISCELLANEOUS

THE building of a library of "synthetic" rates is a worth-while venture. By intelligent use of it, the time study department are saved time, estimating is reduced to a formula, and rates in dispute in the shop can be checked against the library. Another very good use to which it can be put is periodically to check the rating efficiency of the time study personnel and thus be able to ensure a continuity of standard. This library will take a very long time to build up, and, further, needs to be kept scrupulously up to date.

MASTER STUDY CARDS

As each member of the time study department takes a study, so the relevant information that is required for the compilation of the synthetic is transferred to a Master Study Card. These are best filed under operational order. For instance—

All drilling operations under "Drill" (subdivided into type of drill press).

All lathe operations under "Lathe" (subdivided into type and size of lathe).

Assembly operations need different treatment. They should be filed under specific elemental breakdowns, e.g.—

Solder operations under "Solder" (subdivided into type of iron).

Screw operations under "Screws" (subdivided into tool used and size of screw).

Plating under "Metal Finishing" (subdivided into vats used).

Spraying under "Spraying" (subdivided into metal used and method).

Coil winding under "Coil Winding" (subdivided into wire gauge, number of turns and size of bobbin).

The form should be fairly large, about quarto size, and should carry the elemental or operational description at the head, and should be laid out as shown in Figs. 45 and 46.

It will be observed that not all the elements for this operation, cleaning off excess Bakelite varnish, have been included Only those elements which can be considered "basic." Reference to the time study write-up would reveal that Elements 1, 2, and 3 have been excluded from the master study record, because they are concerned with procuring from stores, setting the machine, and obtaining

MASTER
FILLED
BY ... W. Jones
DATE ... 26/9/42

FILE UNDER · "Cleaning" "A"
Bakelite "B"
Varnish "C"

MASTER STUDY CARD

OPERATION Cleaning Excess Bakelite Varnish

MECHANICAL. ✓
HAND

ELEMENT	SELECTED TIME (Mins)	EXTRACTED FROM.	TIMESTUDY SHEET No.	OBSERVER	DATE.	ALTERATIONS (STUDY NO)	MASTER DATE.
Feed Bobbin to Winder	25	Element 4	F 538	Blackstone	14/8/42	—	—
Start m/c & hold sandpaper Block against bobbin to remove excess varnish (Speed of spindle 1000 r.p.m.)	·38	5	do	do	do	—	—
Stop m/c extract, glance inspect & aside left	$\boxed{\cdot 12}$	" 9	do	do	do	—	—
Element 9 altered on 14/12/43 due to inspection by gauge, so :- Stop m/c extract, up gauge try "go & no go" & aside, if rejected for "no go" pass to scrap, time includes ·75% reject allowance	·22	" 9	F 538	Billing	14/12/43	F 972	10/12/43

Fig 45

This is an example of a master card used for the compilation of synthetic information. The points to observe about it are that it must contain (1) The source of information together with any alterations, (2) as full details as possible, (3) an easy method of constant filing. (In order that the filing method *is* constant, the filing instructions should be printed on the card itself.)

MASTER FILLED BY W. Jones

DATE 10/9/42

FILE UNDER Turn "A"
Brass 1/4" "B"
Herbert "C"

MASTER STUDY CARD

OPERATION	TOOL	SPEED	FEED	MATERIAL	MACHINE NAME
Turn & Part off	H/S.	2500.	·008"	Brass 1/4" O	Herbert O

ELEMENT	SELECTED TIME (Mins)	EXTRACTED FROM	TIME STUDY SHEET NO	OBSERVER	DATE	ALTERATIONS STUDY NO	MASTER DATE
Feed to stop, turn 1" & return	1·09	Element 3	G 361	Minns	30/8/42	—	—
Part off	02	" 4	do	do	do	—	—

Fig 46

This is a very similar lay-out to the one previously described except that, as it will mainly be confined to the machine shops, the presentation is slightly different, the main difference being that it contains the very necessary detail regarding tools, speeds, feeds, and material.

replacements of consumable items, which, in this particular instance, is the sandpaper. Elements, 6, 7, and 8 dealt with touching up high spots on the other end of the bobbin, which operations do not properly lie within the scope of "synthetics"

From the example it will be seen that an alteration took place When this occurs, the clerk will place a "box" round the element to be altered but will not mutilate it in any other way. This is because the element may be needed for another job, which will not require the same careful scrutiny that brought about the alteration.

The need for the time study sheet number to be again quoted is entirely dependent upon the filing system adopted by the department for its studies. Where altered, cancelled, or substituted studies are filed separately, then the inclusion of both time studies number is obviously required

This method of recording, if used for machine shop work, would also carry the speeds and feeds, but it should be noted that in this latter case the material used must also be specified and, therefore, a slightly different type of master study card is required. (See Fig 46.) Much the same routine is followed, the outstanding differences being that the element description is necessarily limited and that much more detail is required.

Some jobs and operations lend themselves to "synthetic" control much more easily than others; for instance, blanking. Here, not only can a table be compiled, but the judicious plotting on a graph will help materially in the easy location of the required rate The table on page 198 gives some details of blanking on a guillotine, mild steel, and in Fig. 47 will be seen a graph that correlates this information.

It will be realized that the above examples can give only a general outline of the sort of service that can be built up by a department. Needless to say, a table of "synthetics" is worth a great deal of money, and probably the time is not far short when these tables will be marketed in the same sort of way that vital statistics are issued by the various trade associations.

INVESTIGATIONS

From time to time the need for an investigation into a group or shop will become necessary. Usually the condition that gives rise to this is that the group or shop is apparently unable to make any bonus. A much more serious slant on this is that production is not being made, or if it is then there must be an overloading of

Area (sq. in.)	Hours per 1000	Blank per Hour	Minutes Blank	Area (sq. in)	Hours per 1000	Blank per Hour	Minutes Blank
50	10 0	100 0	0 600				
55	10 5	95·0	0·630	280	19·0	34 50	1·740
60	10·8	92 5	0·648	285	29 3	34 10	1·758
65	11·2	89 0	0·675	290	29 8	33·60	1·788
70	11 8	84·5	0·710	295	30 0	33·33	1·800
75	12·0	83·2	0 720	300	30 8	32·50	1 850
80	12·5	80·0	0·750	305	31·0	32 30	1·860
85	13·0	76·8	0 782	310	31 5	31·75	1·890
90	13·2	75·7	0·791	315	31 8	31 42	1·910
95	13·8	72·5	0·827	320	32·0	31 40	1·920
100	14·0	71·3	0·841	325	32 5	30 80	1 950
105	14·5	69 0	0 870	330	33·0	30 00	2 000
110	14 8	67·5	0·890	335	33·5	29·82	2·005
115	15 1	66 2	0 905	340	34 0	29·40	2·000
120	15 8	63 2	0·950	345	34 2	29 10	2·050
125	16 0	62 5	0·960	350	34 8	28 70	2·082
130	16 5	60·0	0·990	355	35·0	28 50	2·108
135	17 0	58 8	1 020	360	35·5	28 10	2·128
140	17·3	57 8	1·040	365	36 0	27 70	2·160
145	17 8	56 1	1 070	370	36 2	27·60	2·178
150	18 0	55·5	1·080	375	37 0	27·00	2·222
155	18·5	54·0	1 111	380	37 2	26·90	2·230
160	19 0	52·6	1·140	385	37 5	26 70	2·225
165	19 3	51·8	1·160	390	38 0	26 30	2·280
170	19·9	50·2	1·195	395	38 5	26·00	2·309
175	20·1	49·8	1·208	400	39·0	25·64	2·340
180	20·5	49 5	1 212	405	39·4	25·40	2 360
185	21·0	47 6	1·261	410	39 7	25·20	2·382
190	21·5	46·5	1 290	415	40·0	25·00	2·400
195	21·8	45 9	1 340	420	40 5	24 70	2 430
200	22·2	45·0	1 333	425	41·0	24 40	2 460
205	22 8	43·9	1·368	430	41 3	24·20	2 480
210	23 0	43 5	1·350	435	41·8	23 90	2 510
215	23·5	42·6	1·408	440	42·0	23·80	2 520
220	24 0	41·7	1·440	445	42·5	23·50	2 550
225	24·3	41·0	1 465	450	43·0	23 22	2·580
230	25 0	40·0	1 500	455	43·2	23·20	2·585
235	25 1	39·5	1·505	460	43 8	22·82	2 620
240	25·5	39·2	1 530	465	44 0	22 72	2·640
245	26·0	38 2	1·560	470	44·5	22 50	2·670
250	26 5	37 8	1 578	475	45 0	22 20	2·700
255	27 0	37 0	1·621	480	45·5	22 19	2·730
260	27 3	36 6	1·640	485	45·8	21 80	2·750
265	27·6	36·3	1 655	490	46 0	21 78	2·760
270	28 0	25 7	1 680	495	46·5	21·50	2 790
275	28 5	35·1	1 710	500	47 0	21·30	2 818

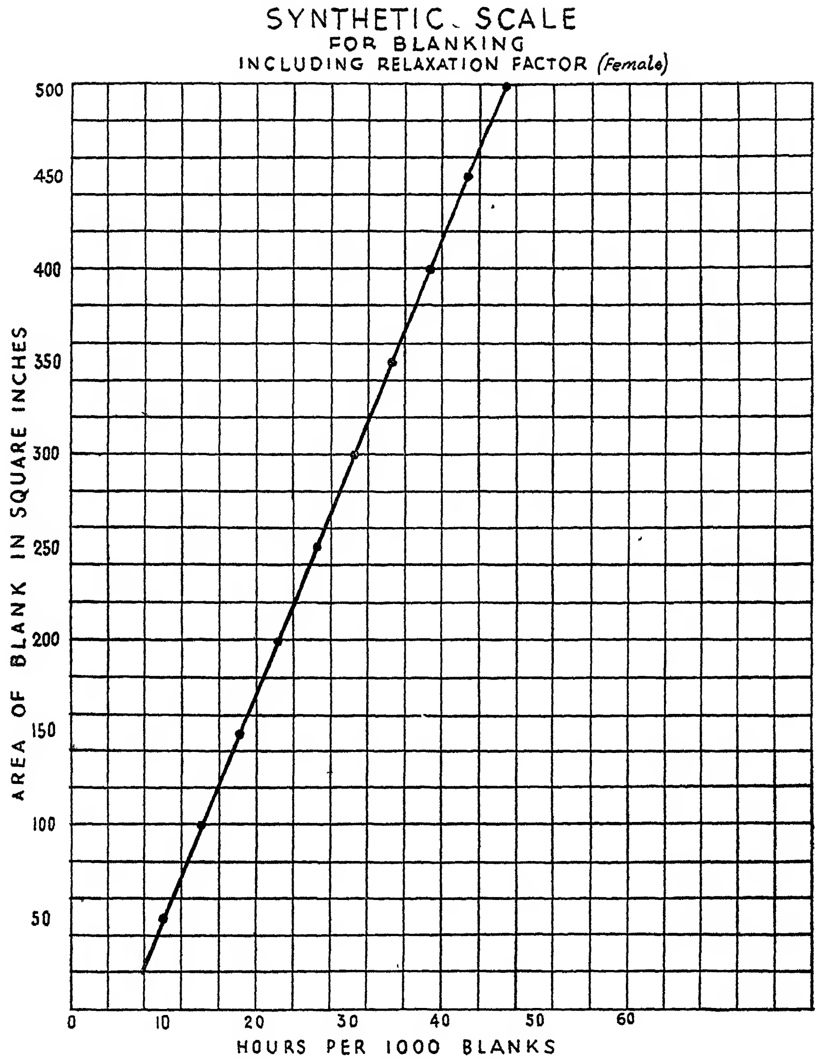


FIG 47

When the table shown on page 198 has been prepared it can be graphed as above, thus making it very easy to localize any particular rate, provided that the area of the blank is known This graph includes the relaxation factor for a female, which is quite high Thus, if a male operator were being used on the job, the rate would have to be adjusted to meet the case.

operators, which, because it involves a higher cost-ratio, is a matter for concern.

Another cause for investigation is the consistently high bonus earnings. Now, if the bonus earnings are really high in comparison

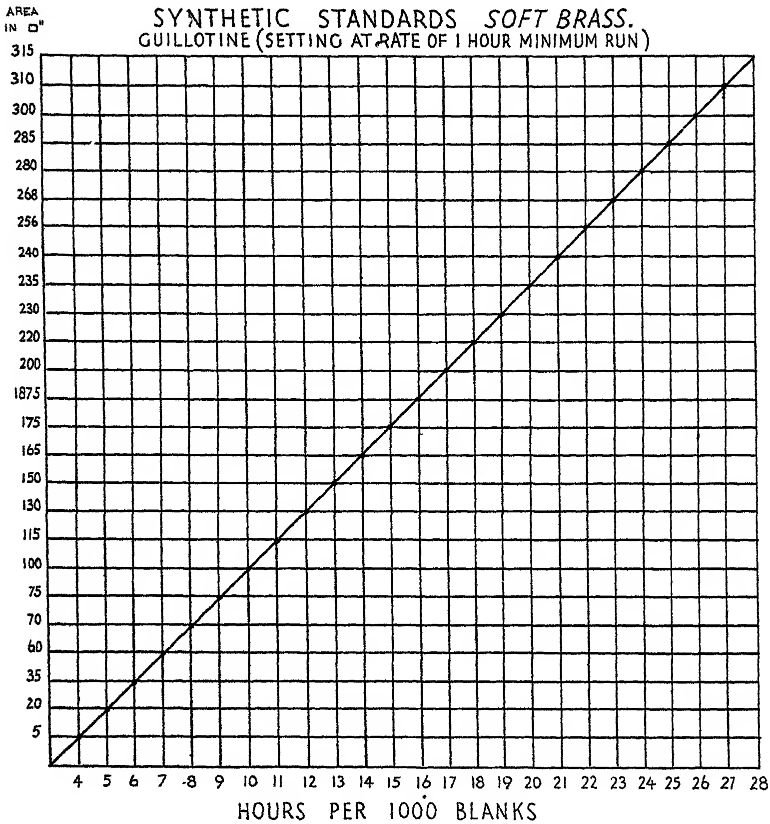


FIG 48 EXAMPLE OF GRAPHING

A guillotine operation, but differing from Fig. 47 This includes setting time and is for a setter-operator (male).

with other shops or groups, operator trouble is bound to result. Invidious comparisons will always be made, and generally it is possible to "spotlight" the reason to the satisfaction of the complaining parties. However, where this is impossible and the bonus earnings remain consistently high, then an investigation will have to be initiated in order to determine the reason.

Therefore, there are two distinct classes into which investigations fall—

(*a*) Where bonus earnings are nil or below the level of expectation.

(*b*) Where the bonus earnings are inordinately high

In either case it is very desirable to have a plan before the investigation takes place

In the case of (*a*) it is suggested that there is a "trouble shooting" team consisting of a time study observer (never the same one who set the original rates), a "methods man" or somebody versed in motion economy, and a person representing the shop supervision, preferably an under manager or a senior foreman.

The following "route" is an indication of the working of the plan. It is assumed that it is designed for an investigation into a whole shop and is based on the fact that (*a*) is the *raison d'être*.

INVESTIGATION PLAN

Section I. Fault Finding

A. Select group, paying due regard to the number of operators, twelve operators losing 25 per cent of output is of much greater importance than two operators losing 150 per cent of output

B. Check stores position.
   (1) If low and consumption high
   (2) If high and consumption low.
   (3) Any two of above combinations.

C. Check existing rates.
   (1) Are rates "actual," i e not estimates or synthetics?
   (2) Are rates loose? Tight?
   (3) Are proper fatigue allowances given?

D. Search for condition affecting *output*.
   (1) Congestion.
   (2) Lighting.
   (3) Poor service.
   (4) Excessive waiting time.

E. Search for condition affecting *bonus*.
   (1) See C (1), (2), and (3).
   (2) Inspection hold-ups.
   (3) Paper work accuracy
   (4) Bad workmanship (rejects).

F. Check operational lay-out.
   (1) Flow of work
   (2) Balance: (2*a*) work; (2*b*) operators.
   (3) Operations in correct sequence
   (4) Can operations be: (4*a*) split, (4*b*) amalgamated?

SECTION 2. FAULT CORRECTING

A "Group Selection."

Explain to operators reason for investigation, and take operators into confidence.

B Stores position.

(1) If low and consumption high, defer changes that will restrict production, however temporary.
(2) Experiments can be made with a certain degree of safety if stores position is sound and future "calls" provide a safety margin.
(3) If stores position is low and consumption low, a greater degree of care must be exercised.
(4) If stores position is high but consumption rapid, the remarks in (3) will apply.

C. Existing rates.

(1) If rates are synthetic or estimated, the jobs should be time-studied to check accuracy.
(2) If rates are found to be loose, they should be left for a period (until near completion of correctives), if tight, they should be loosened forthwith.
(3) Fatigue allowances should be reconsidered in light of existing conditions and *temporary* allowances made if necessary.

D. Condition affecting *output*.

(1) Congestion should be remedied where possible by re-spacing bench (although this condition will right itself as operator-speed increases and operator-need decreases).
(2) Poor lighting affects output; correct by re-seating operators or re-locating lighting.
(3) Improve service of supplies, solder, wire, solder bits, etc (also check bit temperature).
(4) Operators cannot be expected to work hard for three hours and wait for two hours. The stores position should always be borne in mind, and, if necessary, the number of operators reduced, so that some operators can be fully employed all the time rather than all the operators being employed for some of the time. For this purpose a stores control board should be used by the investigators during the "cleaning up" process.

E. Conditions affecting *bonus*.

(1) Rates have already been dealt with under C (1) and (2).
(2) Inspection hold-ups are sometimes inevitable, but a great deal can be done to mitigate hold-ups by co-operation with inspectorate—establishing an even flow of work and by careful "siting" of inspectorate to reduce trucking.
(3) Paper work, by virtue of the fact that it passes through so many hands, is a fruitful source of error. The investigators should check the paper work every morning, particular attention being paid to the number of parts produced against the number of parts recorded, the time taken, the group allocation, and the reconciliation of parts passed and the allowed hours.

(4) Rejects cause loss of bonus because of the time spent in rectifying them. Every endeavour should be made to improve workmanship, and, in particular, efforts should be made to identify operators with specific faults.

F. Operational lay-out.

(1) Work flow—this should be studied with a view to getting maximum runs with the least interference possible from change-overs, etc. Operations should be broken down as much as possible in order to stimulate operator interest and relieve boredom.

(2) Balance is required both in work flow and operator efficiency. Operators should be balanced as equally as possible with just a slight bias at the end, in order that the flow down the line shall be smooth, but leaving enough work at the end to avoid waiting time at a change-over period. Operators need balancing. Slow operators who are beyond hope should be dispensed with.

(3) Often operations will be found out of sequence. A close study of the job should be made in order to discover if the assembly of a part can be speeded up by either moving the operation back or by shifting a previous operation forward.

(4) Attention should be paid to the splitting or amalgamation of operations. Some operations lend themselves to being divided into several elements, others can be speeded up by amalgamating two similar elements

Section 3. Improving Output

Output can generally be improved by—

A. Increasing operator speed.
B. Making the job "easier" (split operations, etc.)
C Better tooling.
D. Introduction of fixtures.
E. Improvement of conditions.
F. Stimulating the spirit-competitive.

A. Operators will need to be told that they are not working fast enough. This needs to be done tactfully, and before doing so it is necessary that local conditions are right, i.e. there is sufficient material for increased speed over a period and no hold-ups in inspection.

B. "A" can often be accomplished by "disguising" the work. If an operator produced x parts an hour previously and the operation can be split, it can usually be disguised so that the required speed (x +) can be obtained without that "it cannot be done" complex.

C. Improved tooling will quicken up a job. Under this heading is the substitution of power tools for hand tools, more accurate temperature of solder bits, better supply bins, and more rapid replacement of consumable items.

D. The introduction of fixtures will assist in the increasing of speed. Fixtures should aim at freeing the hands and should be quick-operating. If spring-loaded, strong springs requiring physical dissipation of energy to operate should be avoided. Foot-operated clamps should be used where possible, and tools should be "anchored," i.e. prepositioned.

E. Conditions, where possible, should be improved by re-laying out the benches, introducing radial bench bins, using gravity chutes for the traffic of parts, improving seating, and watching out for operator discomfort.

F. The spirit of competition should be engendered. This can be done by means of "target boards" showing different and comparative tables. The introduction of "bonus advice" boards will also stimulate competition, particularly is this so if two groups are engaged on similar operations.

The team will work right through the shop with the time study man always a little in front, as he will be checking rates, and from his reports the need for motion study will be thrown up. It will be seen that methods are indicated as being in need of alteration and improvement, and the observant reader will readily perceive that, since the rates have already been set, the methods should have been cleaned up in the first place, and further, since the groups are unable to make bonus on the existing rates, the introduction of methods will bring a reduction of time allowed in any case, thus seemingly bringing about a reversion to the conditions of not being able to make bonus.

In explanation of this, it must be realized that time studies are not always taken under ideal conditions, but the time study observer, from his intimate knowledge of the conditions surrounding the job, often subconsciously anticipates those conditions with the result that if a rapid improvement in conditions does not take place, the rate, as set, becomes "tight." When it has been decided to improve the conditions under the old rates, the introduction of the new rates should either be deferred or introduced on a sliding scale.

In any case, whether it is absolutely necessary to keep production at a predetermined level or not, the sudden reduction of operators that will be asked for, if the rates are to be met sufficiently for the groups to earn bonus, will have a deleterious effect on production-actual (as distinct from production-potential). This is where the adjustment scale can be applied as shown in Chapter VI. This will, if adapted to standard times (that scale being based on premium bonus), operate to the operator's constant advantage.

The results of the investigation should be made available in report form to all interested parties, not forgetting the charge-hands and junior supervision. Special reference should be made to points that are likely to recur, such as inspection hold-ups and high rejection percentages.

With high bonus earnings ("B"), there can only be two, or possibly three, causes of this. They are—

1. Wrong values set by the time study department in the first place.

2 Changes in methods of working.

3 Errors in computations. This is unlikely to cause consistently high bonus earnings, for it would imply a repetition of an error. What can happen is that the clerical staff have been given the wrong information by the time study department, with the result that they are applying the wrong rates.

In view of the fact that the causes are limited, it should be possible to dispense with the methods man and, while it is probably desirable to have a representative of the supervision on hand with whom to discuss the changes, if discovered, his whole-time attendance is hardly necessary.

Unless the time values are wrong by an absurd percentage, it is unlikely that a whole shop will be showing consistently high bonus earnings. Therefore the investigation will be taken up by the time study man and, apart from a careful perusal of the existing studies, his plan will consist simply of—

1. Selecting groups according to percentage bonus being made, having due regard for number of operators involved.

2. Abstracting those relevant time studies and first checking all the clerical work involved.

3. Where standard parts are kept, showing tolerances allowed for on the time study, checking these with existing values.

4. Checking information held by the wages and costs department against information contained on the time study.

5. Going into the shop and checking the rates by two methods: (*a*) overall times; (*b*) re-studying.

It is advisable to file all information extracted by the investigation; therefore a standard form of report or analyst form is recommended. An example is shown in Fig. 49. Here the complete history is shown, the faults are clearly defined, and the responsibilities allocated

It will be appreciated that unless there is an extremely strong case for reducing time allowed, such as by an alteration in technique or methods, the rates should not be altered. If the time study department commit an error in rating and it is purely an error, then sometimes this can be admitted, but where this is done the operators concerned must be given full particulars in order that their minds may be disabused of the thought that if high bonus is made the rates will be "cut." This is very important, for the suggestion that this can occur will have the effect of limiting maximum production because of the restriction of effort.

FROM TIME STUDY
INVESTIGATION DATE(S) 23/4/5 May 1941
INVESTIGATOR J. Drew

INVESTIGATION REPORT

TO PRODUCTION MANAGER
COPY TO A SHOP FOREMAN MR Rice
B COST ✓
C WAGES ✓
D

PART No PART NAME Bobbin Assembly ORIGINAL STUDIES B 147/165 DATES Jan 5/6/4/40 OBSERVER W. Billship

OPERATION	OLD RATE PCS HOUR	OLD RATE HOURS/100	NEW RATE PCS HOUR	NEW RATE HOURS/100	REASON FOR SUGGESTED CHANGE	CHANGE AGREED	SHOP FOREMAN'S SIGNATURE
Clean & Solder tags	42·5	2 35	90	1 11	Core solder introduced Wire cleaning deleted	Yes	J. Rice.
Wind to bobbin	11·0	9·10	23	4 36	No of turns reduced from 1132 to 398	Yes	J. Rice
Ass. to Core & Connect	7·0	14·2	8·6	11 65	Glue used instead of whipping	Yes	J. Rice
Clean off Shellac	90·0	1·11	—	—	No Change		
Rack to fixture	350	·285	720	·138	Different & improved fixture	Yes	J. Rice
Ass. bobbin	80	1·260	—	—	No change		
Cut Silk & feed to bobbin	35	2 860	70	1 430	Silk cut in bulk	Yes	J. Rice
Locate Coil to base	40	2 5	50	2·0	Error in Time Study	No ✕	
Ass. cover & seal with wax	32	3·12	50	2·0	Method of heating wax (HOT POT) mechanised	Yes	J. Rice.
Reject allowance		·5		·25	Improved technique		
		37·275		22·938	✕ Agreed to leave at	Meeting with	Prod. Man T.S. Chief & Mr Rice 30/5/41

FIG 49
The Report is circulated to all interested parties and is filed for reference. It would be desirable for a copy to be sent to workers' representative

It will be noted that in all the cases quoted, it has been suggested that the check studies should always be done by an independent time study observer. This is to make quite sure that no hidden faults will remain hidden. Human nature being what it is, it is possible that the time study observer who has made a grave error, even if it is purely a mistake and not the result of incompetence, will be reluctant to admit it and will take steps to cover it, thus the real reason for the error will not be fully revealed, and the records will be in danger of perpetuating that error.

Another point is that where the claim for an investigation is based on "tight" rates, it gives the operators concerned more confidence if they know that the check is being made by independent parties; they feel that their interests are being safeguarded and thus co-operation is much more easy to obtain.

Emphasis must be laid on the fact that it is necessary that the time study observer whose rates are being questioned should be fully informed of all that is transpiring, otherwise there will be friction in the time study department itself.

FLOW LINE BALANCE

If the flow line technique is being adopted in the factory, it is desirable that the operators be "balanced," i.e. that each operator on the line has approximately an equal amount of work to do; clearly, if an operator has more than his fellows to handle, the second operator will always be waiting for work.

EXAMPLE "A"

Stage	Operation	Minutes at Bonus Speed at 40 per cent
A	Assemble chassis to fixture with 16 clamps	4·95
B	Assemble 4 stays with 16 chd screws (finger start)	2 05
C	Drive home 16 screws with power driver	1·72
D	Assemble 16 SPW and 16 lock nuts to screws	2 02
E	Drive home lock nuts with power driver	2·07
F	Assemble 2 panels to 2 stays	0·80
G	T/O and assemble 2 panels in 2 stays	0 92
H	Locate 4 chd screws SPW and D/H	1 10
I	T/O and locate 4 chd screws and SPW D/H	1 22
J	Locate 2 end panels to chassis	0 60
K	T/O and locate 2 end panels to chassis	0 72
L	Locate 4 chd screws SPW and D/H	1 10
M	T/O and locate 4 chd screws SPWs and D/H	1 22
N	Assemble dial panel to chassis with 2 Rd Hd and D/H	0 72
O	Apply sleeving to 4 wires on dial	0 92
P	Locate 2 earth tags thru members and lock with 2 6BA chd and D H	0 97
		23 10

2000 per week is required, so—

$$\frac{23{\cdot}1 \text{ min.} \times 2000}{60} = 768{\cdot}33 \text{ hours.}$$

ORIGINAL METHOD (*Stage times various*)

Stage	Operation	Time in Minutes
A	Assemble chassis to fixture with 16 clamps . .	4·95
B	Assemble 4 stays with 16 chd screws (finger start) .	2·05
C	Drive home 16 screws with power driver .	1·72
D	Up and locate 16 SPWs and 16 lock nuts . .	2·02
E	Drive home lock nuts with P/D . .	2 07
F *G*	Locate 2 panels to 2 stays . . . . Turn over and locate 2 panels to 2 stays . .	0·80 0·92
H	Locate 4 chd screws and SPW and drive home .	1·10
I	T/O and locate 4 chd and SPW screws and D/H .	1·22
J	Locate 2 end panels to chassis . . .	0·60
K	T/O and locate 2 end panels to chassis .	0·72
L	Locate 4 chd and SPW to chassis and D/H . .	1·10
M	T/O and locate 4 chd and SPW and D/H . . .	1·22
N	Assemble dial panel to chassis	0·72
O	Assemble sleeving to 4-wires on dial panel . .	0·92
P	Locate 2 earth tags thru members with 2 6BA and D/H	0 97

REVISED METHOD (*Stage time* 1·54 *minutes*)

Stage	Operator	Operation	Time in Minutes
a	I	Locate chassis to fixture . . . *PA* .	1·48 0·06
	II	Up and locate 10 clamps and spin on . . *PA* . .	1·50 0·04
	III	Up and locate 6 clamps and spin on . . (Part of *b*) Position 1 stay with 4 screws . *PA* . .	0·90 0·51 0·13
b	IV	Assemble 3 stays and 12 screws *PA*	1·53 0·01
c	V	Drive home 14 screws with power driver . *PA* . .	1·50 0·04
d	VI	(Part of *c*) Drive home 2 screws with P/D . Assemble 10 SPWs and 10 lock nuts . . *PA* . .	0·21 1·26 0·07
e	VII	(Part of *d*) Assemble 6 SPW and 6 lock nuts Drive home 4 lock nuts with P/D. . *PA* .	0·95 0·52 0·07
f *g*	VIII IX	(Part of *e*) Drive home 12 lock nuts with P/D Locate 2 panels to 2 stays . . . . . T/O and locate 1 panel . . . . *PA* . .	1·56* 0·80 0·54 0 20
h	X	(Part of *g*) Locate 1 panel . . . Locate 4 chd screws SPW and D/H . . *PA* . .	0 40 1 10 0·04
i	XI	T/O and locate 4 chd screws and D/H (Part of *j*) Locate 1 end panel to chassis . *PA* . .	1·22 0·30 0·02
j	XII	Locate 1 end panel to chassis . . . T/O and locate 2 end panels to chassis . (Part of *k*) Locate 2 chd and SPW to chassis *PA* . .	0·30 0·72 0·33 0·19
k	XIII	Assemble 2 chd and SPWs and D/H (4) . (Part of *l*) T/O and assemble 4 chd and SPW	0·77 0·77
l	XIV	Drive home 4 chd with P/D . . . Assemble dial panel to chassis . . . (Part of *m*) Assemble sleeving to 2 wires . *PA* . .	0·33 0·72 0·46 0·03
m	XV	Assemble sleeving to 2 wires . . . . Locate 2 earth tags and D/H . . *PA* . .	0·46 0·97 0·11
		Total *PA* 1·01 minutes. Or 4·35 per cent of total time.	

* This being worth only 6 seconds, will probably be carried easily.

At 50 hours per week per operator—

$$50\overline{)768 \cdot 33} = 15 \cdot 36 \text{ operators.}$$

(The 0·36 (2·4 per cent) can be safely ignored because the bonus speed is almost certain to compensate for it.)

To find *balanced* stage times divide total time by 15—

$$\therefore \frac{23 \cdot 10}{15} = 1 \cdot 54 \text{ min. per stage.}$$

This means that on the flow line principle, each operator must have approximately 1·54 min. work to do. Approximately is used deliberately because it will be evident that it is almost impossible to divide the stage times exactly. To cover this point, if the stage works out at less than 1·54 min., an allowance (*PA*) must be given to compensate the worker for not being able to produce maximum effort, due to the fact that *exactly* 1·54 min work is not available in every work cycle.

Example "B" shows the comparisons between the original method of balancing according to work load and the new method according to time load.

SUMMARY OF FORMULAE USED IN TIME STUDY

Reconciling actual time taken to normal seconds or decimal parts of a minute. Also known as "Time Allowed."

METHOD ONE

Find average time taken Call it A.T.T.

Find average rating. Call it A.R.

Express as $\dfrac{\text{A.T.T.} \times \text{A R}}{60}$ = Normal Seconds (or decimal parts of a minute)

Example:

	Seconds	*Rating*	*Decimal of minute*	*Rating*
	14	52	0·233	52
	12	60	0·200	60
	16	45	0·267	45
	9	80	0·150	80
	9	80	0·150	80
	10	72	0·167	72
Total	70	389	1·167	389

Averages:

11·66	64·8	0·194	64·8

So: $\dfrac{11 \cdot 66 \times 64 \cdot 8}{60} = 12 \cdot 58$ T.A., so: $\dfrac{0 \cdot 194 \times 64 \cdot 8}{60} = 0 \cdot 209$ min. T.A.

Note. If rating is expressed as parts of 100 divide by 100.

Method Two

Based on selective method.

Write down all time taken in order. Against each place rating. Select that time which has greatest recurrent factor and its rating and proceed as above.

Finding Pieces per Hour

$$\frac{3600}{\text{Normal seconds}} = \text{Pieces per hour}$$

Example:

Let normal seconds = 11·66.

$$\therefore \frac{3600}{11\cdot66} = 309 \text{ (approx.) pieces per hour}$$

Finding Hours per Hundred Pieces

$$\frac{100}{\text{Pieces per hour}} = \text{Hours per 100 pieces}$$

Example

Let 309 = Pieces per hour.

$$\frac{100}{309} = 0\cdot323 \text{ hour per 100 pieces}$$

Finding Bonus Earned (Standard Time)

$$\frac{\text{Parts produced}}{\text{Time taken}} = \text{Pieces per hour}$$

Thus $$\frac{\text{Pieces per hour}}{\text{Rate in pieces per hour}} \times 100 = \text{Percentage bonus}$$

Example:

Let parts produced = 120
Let time taken = 0·75 hour.
Let rate in pieces per hour = 100.

$$\therefore \frac{120}{0\cdot75} = 160 \text{ pieces per hour} \quad \therefore \frac{160}{100} \times 100 = 160 \text{ per cent base rate}$$

Finding Bonus from Rate Hours per Hundred (Standard Time)

Parts produced × hours per hundred = Time allowed. Thus—

$$\frac{\text{Time allowed}}{\text{Time taken}} \times 100 = \text{Percentage bonus on time taken}$$

Example:

Let parts produced = 120.
Let hours per 100 = 1·0.

$\therefore$ Time allowed = 1·2 hours.

$$\text{Time taken} = 0\cdot75 \quad \therefore \frac{1\cdot2}{0\cdot75} \times 100 = 160 \text{ per cent base rate}$$

FINDING BONUS MADE UNDER PREMIUM BONUS SCHEME

Parts produced × hours per hundred = Time allowed
Time allowed — Time taken = Time saved. Thus—

$$\frac{\text{Time saved} \times 100}{\text{Time allowed}} = \text{Percentage bonus on time allowed}$$

Express this on Time taken.

Example

Parts produced = 120 $\qquad$ 120 × 1·0 = 1·2 hours
Hours per 100 = 1·2
So—

Allowed hours	1·2
Time taken	0·75
Time saved	0·45

$$\therefore \frac{0{\cdot}45 \times 100}{1{\cdot}2} = 37\ 5 \text{ per cent.}$$

CONVERSION TABLE

DECIMAL MINUTES TO DECIMAL HOURS

Decimal minutes	Decimal hours	Decimal minutes	Decimal hours	Decimal minutes	Decimal hours
1	0 0167	8·25	0 138	32	0 533
1 25	0 0208	8·50	0·142	33	0·550
1·50	0·0250	8·75	0·146	34	0·567
1·75	0 0292	9	0·150	35	0·583
2	0·0330	9 25	0·154	36	0·600
2 25	0·0375	9 50	0 158	37	0·617
2 50	0·0416	9·75	0 163	38	0·633
2 75	0·0460	10	0·167	39	0·650
3	0·0500	11	0·183	40	0·667
3·25	0·0540	12	0·200	41	0 683
3·50	0 0581	13	0·217	42	0·700
3·75	0·0625	14	0 233	43	0·717
4	0·0670	15	0·250	44	0·733
4·25	0·0710	16	0·267	45	0 750
4·50	0·0750	17	0·283	46	0 767
4·75	0·0790	18	0·300	47	0·783
5	0 0835	19	0·317	48	0 800
5·25	0·0875	20	0·333	49	0·817
5·50	0·0920	21	0 350	50	0·833
5·75	0·0960	22	0·367	51	0·850
6	0·100	23	0·383	52	0·867
6·25	0·104	24	0·400	53	0·883
6·50	0 108	25	0·417	54	0·900
6·75	0·113	26	0·433	55	0·917
7	0·117	27	0·450	56	0·933
7·25	0·021	28	0·467	57	0·950
7·50	0·125	29	0 483	58	0·967
7·75	0 129	30	0·500	59	0·983
8	0 133	31	0·517	60	1·000

CONVERSION TABLE

Seconds to Decimal Minutes and Hours

Seconds	Decimal minutes	Decimal hours	Seconds	Decimal minutes	Decimal hours
1	0 017	0·00028	31	0·517	0 0086
2	0·033	0·00056	32	0 533	0·0089
3	0·050	0·0008	33	0 550	0·0092
4	0·067	0 0011	34	0 567	0 0094
5	0 083	0 0014	35	0 583	0 0097
6	0·100	0 0017	36	0 600	0 0100
7	0 117	0 0019	37	0·617	0·0103
8	0·133	0·0022	38	0·633	0·0106
9	0·150	0 0025	39	0·650	0·0108
10	0·167	0 0028	40	0·667	0·0111
11	0·183	0·0031	41	0·683	0·0114
12	0·200	0 0033	42	0 700	0·0117
13	0·217	0 0036	43	0 717	0 0119
14	0·233	0 0039	44	0 733	0 0122
15	0·250	0·0042	45	0·750	0·0125
16	0 267	0·0044	46	0·767	0 0128
17	0 283	0·0047	47	0·783	0·0131
18	0 300	0 0050	48	0 800	0·0133
19	0·317	0 0053	49	0 817	0·0136
20	0 333	0 0056	50	0 833	0 0139
21	0 350	0 0058	51	0 850	0·0142
22	0·367	0 0061	52	0 867	0·0144
23	0 380	0·0064	53	0·883	0 0147
24	0 400	0 0067	54	0 900	0 0150
25	0 417	0 0069	55	0 917	0 0153
26	0 433	0 0072	56	0·933	0 0156
27	0 450	0 0075	57	0 950	0 0158
28	0 467	0 0078	58	0·967	0 0161
29	0 483	0 0081	59	0 983	0 0164
30	0 500	0 0083	60	1 000	0 0167

INDEX